



**The Impact of Technological Diversification on Firm
Performance: Mechanical, Institutional and Optimal
Distinctiveness Views**

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Statement of Originality

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Abstract

Chinese firms are experiencing a rapid increase in technological diversification, which is referred to as maintaining their capabilities in multiple technologies. However, the research on the relationship between technological diversification and firm performance is inconclusive. This PhD thesis tries to re-investigate the technological diversification-firm performance relationship from three different perspectives using data on Chinese listed firms from 2003 to 2014. First, the thesis tries to overcome the shortcomings of previous technological diversification research by unpacking technological diversification into explorative and exploitative technological dimensions from the mechanical view and studying their roles in firm performance. ***The findings suggest that technological diversification that combines explorative and exploitative dimensions is positively related to firm performance. This relationship is conditional on intangible complementary assets and firm type (high or low-tech firms).*** Second, this thesis tries to investigate the technological diversification-firm performance relationship through an institutional view that has hardly been mentioned in the previous literature. Here it is argued that firms try to use technological diversification as a way to gain legitimacy. In order to do so, firms' technological diversification need to be similar to the industrial norms. ***The results reveal a positive relationship between firms' conformity in technological diversification and their performance. The results further delineate the boundary conditions that influence this relationship. While environmental dynamism strengthens the conformity-performance relationship, environmental munificence reduces it.*** Finally, this thesis tries to integrate both a mechanical view and an institutional view of technological diversification and find evidence to support the optimal distinctiveness view that firms should reach a balance between these views. ***The results reveal a curvilinear (inverted U-shaped) relationship between firms' conformity in technological diversification and their performance. I also test the boundary conditions of this relationship. While firm age strengthens the conformity-performance relationship, state ownership weakens it.***

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Chapter 1 Introduction

1.1 Research background

Since the initiation of the ‘open door policy’ in 1978, China, as the largest emerging economy and second largest economy behind the USA, has experienced a significant economic boost. These advances in the economy have also changed the technological landscape in terms of diversification. Technological diversification which related to the degree that organisations obtain capabilities in multiple technologies, has attracted much both scholars’ and practitioners’ attention (Cantwell & Vertova, 2004). The degree of technological diversification in China has increased dramatically since 1986 and the diversification of different regions has also increased and converged (Wang, Ning, & Prevezer, 2015). This indicates from a macro perspective that regions are becoming more and more diversified in multiple technologies. However, this trend may also reflect the increase in the technological diversification of firms in China.

Technological diversification at the firm level is different from that at the regional level. The main difference related to the different capabilities that firms and regions own. At the firm level, the capabilities to conduct technological diversification are limited. Firms are constrained by limited capabilities such as financial resources, human capital among others. This makes the diversification capabilities more rare and valuable among

firms. On the contrary, the regions have relatively abundant capabilities to conduct diversification strategies. As a result, typical organisational theories such as resource-based view (RBV) and institutional view are a better fit to analyse firms' diversification strategies instead of regional diversification.

From a more macro perspective, according to a survey of 100 large state-owned firms and 30 large non-state-owned firms by the Ministry of Commerce of China, the number of firms that diversified increased from 97 in 2011 to 126 in 2015, and the share of diversified firms increased to 96.92% in 2015, from 74.62% in 2011¹. Moreover, since the issue of the National Outline for Medium and Long-term Planning for Scientific and Technological Development (2006-2020) in 2006, central and local governments in China have initiated a bundle of policies to encourage domestic firms to acquire and absorb foreign technologies, which will further increase the propensity for technological diversification in China. However, the research findings on the relationship between technological diversification and firm performance are mixed. As a result, the inconsistent findings, on the one hand, prevent technological diversification research expanding boundaries. On the other hand, increasing firms in China are expanding their technology portfolios without knowing the financial consequences. These firms may not get the profits from multiple technologies that they expected. In

¹ http://paper.people.com.cn/rmlt/html/2016-09/01/content_1724013.htm

conclusion, it is essential to detangle the relationship between technological diversification and firm performance.

Research on technological diversification and firm performance has attracted much attention. Previous studies have proposed three models to illustrate the relationship between technological diversification and firm performance, i.e. the premium diversification model, the discount diversification model, and the U-inverted model, which show positive, negative, and curvilinear effects of technological diversification respectively (Benito-Osorio, Guerras-Martín, & Zuñiga-Vicente, 2012). For example, after analysing the Taiwanese smartphone sector, Chen, Yang, and Lin (2013) found that technological diversification played a negative role in firm performance. Raghuram, Henri, and Luigi (2000); Rumelt (1982) and Vojislav and Gordon (2002) all found negative financial implications of diversification. Chiu, Lai, Lee, and Liaw (2008) also studied Taiwanese firms and found a positive relationship between technological diversification and firm performance. Chiu et al. (2008); Garcia-Vega (2006); Kim, Lee, and Cho (2016); Miller (2006); Zander (1997) and Lin and Chang (2015) all found similar positive financial implications of technological diversification. Du, Lu, and Guo (2015) found an inverse U-shaped relationship from 134 Chinese machinery and equipment manufacturing firms. Similarly, Leten, Belderbos, and Van Looy (2007); Lubatkin and Chatterjee (1994) and Manuel and Simi (2002) all indicated the non-linear

relationship between diversification and firm performance. This U-inverted model is the combination of the premium and discount model which not only stress the benefits of diversification but also the cost of multiple portfolios. As a result, this model believes the relationship between technological diversification and firm performance is not straightforward. In conclusion, the research results are rather mixed in terms of the relationship between technological diversification and firm performance.

Although there is practical evidence that more and more firms in China are becoming technological diversifiers, scholars of technological diversification have not reached a consensus regarding its role in firm performance. Both the benefits and costs of technological diversification have been discussed in previous literature. These ambiguities not only theoretically limit the applications of technological diversification logic in predicting improvements in performance but also practically limit the provision of guidelines for firms in regard to implementing diversification strategies to enhance their technological capabilities.

The inconsistencies in the findings of this studies stem from three main issues. First, the measures of diversification that used before are incomplete. The current operationalisations effectively take a mechanical view of technological diversification that regards it as firms' rational pursuit of profit. This stream of literature often measures

technological diversification based on ‘the breadth of a body of knowledge’, but ignores ‘how far a firm pursues links in the knowledge network’ (Miller, 2006). Also, traditional measures of technological diversification are sensitive to firms’ portfolio composition, which can create ambiguities (Robins & Wiersema, 2003). Thus, a more comprehensive measure of technological diversification should be incorporated to fully capture both ‘how far’ and ‘how deep’ firms pursue knowledge in regard to linking multiple technologies.

Second, the conclusions of previous research have been drawn based on the logic of consequentiality, that is, technological diversification is considered ‘atomic behaviour’ and ‘instrumental actions’ to influence output. Previous studies have characterised technological diversification as a rational decision or strategy that can bring synergy to existing technology portfolios or act as a resource to build competitive advantage (Corradini, Demirel, & Battisti, 2016; Kim et al., 2016). This logic of consequentiality, however, fails to provide sufficient evidence to explain why, in some circumstances, technological diversification benefits firm performance, while in others it does not. That is to say, this perspective does not “recognise the potential influence of market actors ... about the sources or criteria of organisational efficiency” (Zajac and Westphal, 2004: 434). Firms are embedded in an institutional environment and socially situated context (Westphal & Zajac, 2013). The interpretation of firms’ strategies, such as technological

diversification, is socially constructed and constituted. Thus, firms' strategies, such as technological diversification, should also be considered in the larger context, as an institutional strategy, rather than simply as an individual organisation's rational activity. However, research that considers technological diversification from an institutional perspective in terms of its role in firm performance is limited. Most of the research, based on a mechanical view, is under-socialised.

Thirdly, some recent advances suggest that focusing on either institutional perspectives or mechanical views of technological diversification is problematic in regard to improving firm performance (Zhao, Fisher, Lounsbury, & Miller, 2017; Zuckerman, 2016). Thus, if the mechanical view and institutional view of technological diversification both hold, focusing on either side of technological diversification may also result in ambiguity regarding the financial implications. In this regard, the integration of the two perspectives of technological diversification not only reflects the recent theoretical advances in optimal distinctiveness, that is, that firms should reach a balance between a mechanical view to differentiate and an institutional view to conform, but can also provide new evidence regarding the technological diversification-firm performance relationship.

1.2 Statement of purposes

In this Ph.D. thesis, I try to solve the aforementioned three problems above that may

result in inconsistency in the technological diversification-firm performance relationship based on data from Chinese listed firms. Specifically, I first argue that technological diversification is not a monolithic construct. Miller (2006) proposes that technological diversification refers to the diversity of a firm's research portfolio and the depth to which a firm pursues links in its knowledge network (Miller, 2006: 606). This definition incorporates two dimensions of technological diversification that are largely ignored in the literature. I argue that the perspective of technological diversification relating to exploration has been extensively discussed, while the other perspective, relating to exploitation, has drawn little attention in previous technological diversification literature. I unpack technological diversification into two perspectives, i.e. explorative technological diversification and exploitative technological diversification. Moreover, I also provide an operationalisation of both aspects of technological diversification and study how a more comprehensive view of technological diversification may affect firm performance. This chapter is based on a mechanical view of technological diversification, like most of the previous research. However, it contributes to the literature by unpacking and operationalising explorative and exploitative technological diversification respectively.

Next, I try to provide new information regarding the technological diversification-firm performance relationship from an institutional perspective. To be specific, I try to

understand the technological diversification in the larger institutional context in which firms are embedded. That is, firms' technological diversification patterns should be similar to those of their competitors in order to conform to the industry recipe and further gain organisational legitimacy. I explain the roles of technological diversification in firm performance through this isomorphism, which confers legitimacy and resources on companies (Deephouse, 1996; Suchman, 1995). This logic of appropriateness from an institutional view is significantly different from the logic of consequentiality (rational perspective) that has been used in past technological diversification research (also in the last chapter). This view argues that firms' strategic positioning and decisions may not be entirely rational and may just be a response to institutional pressure. The institutional theory may serve as an antidote to the over-rationalist and technocratic perspective (Greenwood, Oliver, Sahlin-Andersson, & Suddaby, 2008). In this way, explaining the technological diversification-firm performance relationship from a different angle may provide a complementary explanation beyond the mechanical view.

Third, this thesis tries to reflect on recent theoretical advances in optimal distinctiveness and combine both perspectives mentioned above (i.e. the mechanical and institutional perspectives) regarding technological diversification. Specifically, I aim to integrate both aspects of technological diversification and build a framework that explains how

a trade-off between the mechanical view and the institutional view can contribute to firm performance. I also investigate how this trade-off may change in terms of firm characteristics. I believe that in this way this chapter will contribute to the technological diversification literature by theoretically integrating both aspects and empirically testing the contingencies of the trade-off.

Finally, in the last section, I will discuss the main findings in the previous chapters. I will propose a framework that synthesises the mechanical and institutional views of technological diversification and the key contingencies of each view of technological diversification. I will also try to indicate some key mechanisms that may change the technological diversification-firm performance relationship that this PhD thesis does not address. Specifically, encouraged by recent advances regarding the mediation effect between firms' resources and firm performance (Li-Ying, Wang, & Ning, 2016), I argue that more research can be done to add to the technological diversification literature through investigating more conditions that mediate the technological diversification-firm performance relationship. Future research could be enlightened and encouraged through this framework.

1.3 Research questions and hypothesis

This Ph.D. thesis firstly reviews the literature on technological diversification, regarding the mechanical perspective, the institutional perspective and the optimal distinctiveness view related to the trade-off between differentiation and conformity in terms of technological diversification. The next three chapters empirically test the technological diversification-firm performance relationship through three different but complementary aspects. The core question that I try to answer in this PhD thesis is: *Does firms' technological diversification relate to firm performance?* Chapter 3 answers this question from a mechanical view combining explorative and exploitative technological diversification. I also investigate two boundary conditions of this relationship. I propose three hypotheses in this chapter:

H3.1: Technological diversification that considers both the explorative and exploitative perspectives has a positive effect on firms' performance.

H3.2: Technological diversification is more effective in promoting firms' performance in low-tech firms than in high-tech firms.

H3.3: Complementary assets positively moderate the relationship between technological diversification and firm performance.

Chapter 4 aims to investigate the technological diversification-firm performance relationship from the angle of institutions. I explain that technological diversification can lead to superior firm performance through conforming to the ‘industry recipe’ (Spender, 1989). I also investigate two contingencies that may change this relationship. I propose three hypotheses in this chapter:

H4.1: Firms’ conformity to their industry norms in terms of technological diversification is positively associated with firm performance.

H4.2: The higher the environmental dynamism, the stronger the relationship between firms’ conformity in technological diversification and performance.

H4.3: The higher the environmental munificence, the weaker the relationship between firms’ conformity in technological diversification and performance.

Chapter 5 integrates the two perspectives and investigates how optimal technological diversification conformity enhances firm performance. I argue that there is a trade-off between the mechanical view and institutional view of technological diversification. Therefore, optimal technological diversification conformity relates to firm performance.

I will adopt two complementary ways to test this argument. First, I construct a measurement by multiplying the construct of technological diversification from both mechanic view and institutional view. If the coefficient of this interaction is negative and significant, the replacement effect between differentiation and conformity in regard to technological diversification will be concluded. Second, I aim to investigate the non-linear relationship of technological diversification conformity. If the inverse U-shaped relationship is observed, then I can confirm that there is a trade-off between differentiation and conformity in terms of technological diversification. I will also explore two boundary conditions under this circumstance. I propose three hypotheses in this chapter:

H5.1: There is an optimal level of technological diversification conformity that relates to firm performance. That is to say, there is a trade-off between technological diversification as a differentiation activity and conformity.

H5.2: State ownership negatively moderates the relationship between technological diversification conformity and firm performance.

H5.3: Firm age positively moderates the relationship between technological diversification conformity and firm performance.

1.4 PhD Thesis Outline

This PhD thesis addresses the technological diversification-firm performance relationship through three different and complementary angles. Figure 1-1 illustrates the overall research framework of this thesis.

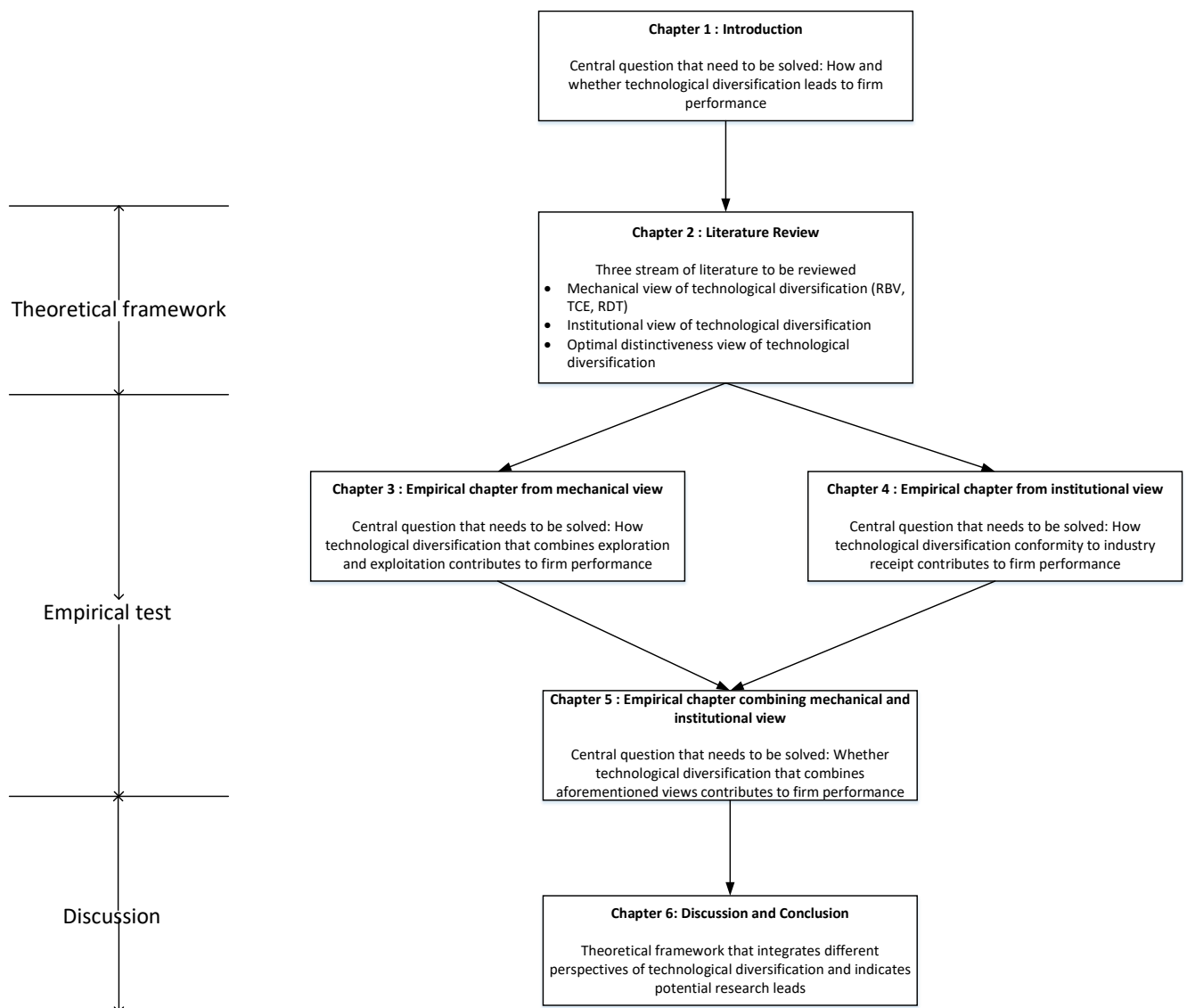


Figure 1- 1 Overall research framework of the PhD thesis

After this section, I will review the literature that explains why firms engage multiple technologies. Specifically, I will explain technological diversification from a mechanical view, which incorporates RBV, TCE and RDT. Then, I will try to understand technological diversification as a way to legitimate firms' behaviour from an institutional view. Lastly, I will try to combine the two perspectives of technological diversification and explain technological diversification in the light of the recent theoretical advances regarding optimal distinctiveness, whereby it is believed that there is a trade-off between the mechanical view and institutional view of technological diversification. The propose of this chapter is to build a theoretical framework that can provide a foundation for the following empirical tests.

Chapter 3 empirically investigates the technological diversification-firm performance relationship from a mechanical view. According to this view, firms perform better if they have a higher degree of technological diversification. However, the previous literature based on a mechanical view of technological diversification mostly considers the exploration of multiple technologies. This biased view ignores the fact that there is also exploitation in technological diversification (Montgomery, 1994). For example, Miller (2006) defines technological diversification as the “breadth of a body of knowledge and from how far a firm pursues in a knowledge network” (Miller, 2006:

606). This concept, on the one hand, regards technological diversification as exploration, which can be understood as firms engaging in explorative activities to search for knowledge and reduce the risk of innovation. On the other hand, this concept also emphasises how firms adopt exploitative activities to refine their knowledge and deepen their understanding of expanded technology domains. Angelo, Antonio Messeni, and Achille Claudio (2017) acknowledge that firms who undertake explorative technological diversification may “not be able to develop sufficient capabilities and understanding in each technology domain” (Angelo et al., 2017: 1251). Their work implies that exploitative activities in multiple technologies are necessary. In this chapter, I try to understand technological diversification from a mechanical view with the combination of exploration and exploitation dimensions at the same time.

Chapter 4 investigates the technological diversification-firm performance relationship from an institutional view, a perspective that takes different foundation from mechanical view. According to the logic of consequentiality, technological diversification is considered ‘atomic behaviour’ and ‘instrumental actions’ to influence output from a mechanical view. The logic of appropriateness from an institutional view, by contrast, emphasises socially constituted and culturally framed rules and taken-for-granted norms (March & Olsen, 2008). In this sense, firms choose to expand their technology scope as a response to institutional pressure and to achieve isomorphism,

that is, to be legitimated by key constituencies and get access to resources (Greenwood, Raynard, Kodeih, Micelotta, & Lounsbury, 2011). In this chapter, I thus try to understand technological diversification from the logic of appropriateness, which has been largely ignored in the previous literature. According to this logic, technological diversification is a way to seek social approval and recognition, which increases the survival rate and secures support from key constituents. This concept of technological diversification eclipsed the long-standing notion that technological diversification is firms' intentional strategic planning to seek profit.

Chapter 5 investigates the technological diversification-firm performance relationship by combining the mechanical and institutional views. Building on the strategic balance viewpoint (Deephouse, 1999; Zuckerman, 2016), I argue that firms should reach a balance between differentiation and conformity in technological diversification that can generate abnormal rents for them. That is to say, there is a need for a trade-off between technological diversification as a differentiation strategy from a mechanical view and a conformity strategy from an institutional view. A singular focus on either differentiation or compliance could be detrimental to firms' performance. In other words, moderate technological diversification conformity can contribute to firm performance, while low or high compliance does not. A high level of technological diversification conformity will result in a firm facing severe competition and generating low rents, while a low

level of technological diversification conformity will lead to firm suffering from legitimacy challenges that will compromise firm performance. In this chapter, I try to prove the trade-off hypothesis in two ways. First, I multiply technological diversification, which combines the explorative and exploitative perspectives, by technological diversification conformity. If the coefficient of this interaction is negative and significant, the replacement effect between differentiation and compliance in terms of technological diversification will be concluded. Second, I try to investigate the non-linear relationship of technological diversification conformity. If the inverse U-shaped relationship is observed, then we can confirm that there is a trade-off between differentiation and compliance in terms of technological diversification.

Chapter 6 summarises the empirical findings of the previous chapters and integrates them into a framework. Moreover, I point out some fundamental mechanisms that may change the technological diversification-firm performance relationship that this PhD thesis does not address. I mainly concentrate on the boundary conditions of technological diversification discussed in previous chapters. However, there may also be a mediation effect that may alter the technological diversification-firm performance relationship. I thus review the recent and related literature and suggest potential mediators to encourage future research.

1.5 Why China?

I chose China as the research setting for several reasons. First, as an emerging economy, China lacks well-established institutions such as market infrastructure and legal systems. In Western countries, firms' strategies rely less on these institutions, as they are largely taken for granted and it is easy to forget the various norms and regulations that promote economic transactions (Ingram & Silverman, 2002). Therefore, institutions "[fade] into the background as control variables" (Meyer and Peng, 2016: 14). However, in emerging economies such as China, institutions are pushed to centre stage and "directly determine what arrows a firm has in its quiver" (Ingram and Silverman 2002: 16). This makes China an ideal context in which to study the roles of institutions.

Second, I had easy access to the data on Chinese firms. SIPO provides comprehensive and detailed data for Chinese firms, which I used to calculate the technological diversification. Moreover, CSMAR also provides accurate firm-level financial and other related data, which facilitated my research. As a result, the data available provided easy solutions for me in my attempt to link the mechanical and institutional views of technological diversification.

Chapter 2 Data and Methodology

To carry out empirical analysis, it is necessary to select appropriate data sources and methodology. This chapter aims to describe the data sources used in this PhD thesis and introduce the dataset compilation for the practical analysis in detail. Previous research has adopted various methods to study firms' diversification, including case studies (Watanabe, Matsumoto, & Hur, 2004), managerial surveys (Beattie, 1980), literature reviews (Martin & Sayrak, 2003) and econometric regressions (Acosta, Coronado, & Martínez, 2015; Corradini & De Propriis, 2015; Corradini et al., 2016; Kim et al., 2016). Given that I needed to test the diversification-firm performance relationship based on different theoretical perspectives, this PhD thesis adopted econometric analysis in each empirical chapter.

The remainder of this chapter is organised as follows. Section 3.1 elaborates the two key database sources adopted in this PhD thesis, namely the China Stock Market and Accounting Research (CSMAR) database and the patent database from the State Intellectual Property Office of the People's Republic of China (SIPO). Section 3.2-3.4 expatiates on the data collection, the variable definitions, and the econometric configurations for Chapters 4, 5, and 6.

2.1 Data source and sample selection

In order to answer the question regarding how and whether technological diversification relates to firm performance, two independent data sources were used at the firm-level to test the hypothesis. The first one was CSMAR, from which I collected firm-level demographic data including financial data and corporate governance data, among others. As I aimed to investigate the relationship between technological diversification and firm performance, patent data were also needed to calculate the diversification. In order to collect this data, I used a web crawler to search the website of SIPO. The details can be found below.

The China Stock Market and Accounting Research (CSMAR) database

CSMAR serves as the primary source of information on Chinese stock markets and the financial statements of China's exchange-listed firms. It has been developed by Guo Tai An Information Technology (GTA) in collaboration with the University of Hong Kong and the China Accounting and Finance Research Centre of Hong Kong Polytechnic University; this database covers the ownership, board of directors, and financial data of all listed firms in China since 1992 (Greve & Man Zhang, 2017). This dataset has been found to be reliable and is used extensively in work regarding Chinese firms' governance performance (Zhang & Qu, 2016), social responsibility behaviour (Marquis & Qian, 2014), outward foreign direct investment (Xia, Ma, Lu, & Yiu, 2014)

and other related management fields. In this thesis, I select all firms that listed on the main board of Shenzhen and Shanghai Stock Exchanges.

Patent data from the State Intellectual Property Office of the People's Republic of China (SIPO)

SIPO records information about every patent, including the application number, publication number, invention title, applicant, priority number, abstract, agent, inventor, claims, IPC classification number, publication date and application date. The IPC classification number was used to measure firms' technological diversification; the applicant was used as the keyword to match the listed firms; and the application date was used to identify the year to calculate the technological diversification. However, these data are not available for large-scale download. As a result, I used a web crawler to download the data following two steps.

First, I drew on the WIND database, a Compustat-style database used in China to identify the names of listed Chinese firms, their former names (if any), and their subsidiaries (see <http://www.wind.com.cn>). This approach was necessary because listed firms often change their names or establish new subsidiaries when the ownership structure changes. Second, I used the listed firms' names as the key variable and matched this content to the web crawler on SIPO's website (<http://www.pss-system.gov.cn/sipopublicsearch/portal/uiIndex.shtml>). Below is the user interface of SIPO; the web crawler searched the patent application of each listed firm.

高级检索

清空配置

申请号	<input type="text"/>	?	申请日	=	<input type="text"/>
公开 (公告) 号	<input type="text"/>	?	公开 (公告) 日	=	<input type="text"/>
发明名称	<input type="text"/>		IPC分类号		<input type="text"/>
申请 (专利权) 人	<input type="text"/>		发明人		<input type="text"/>
优先权号	<input type="text"/>	?	优先权日	=	<input type="text"/>

Figure 2- 1 The user interface that identifies the patent applicant in Chinese

Application No.	<input type="text"/>	?	Application Date	=	<input type="text"/>
Applicant	<input type="text"/>		Inventor		<input type="text"/>
Publication No.	<input type="text"/>	?	Publication Date	=	<input type="text"/>
Priority	<input type="text"/>		IPC Classification No.		<input type="text"/>
IPC Main Classification No.	<input type="text"/>	?	IPC Secondary Classification No.		<input type="text"/>

Figure 2- 2 The user interface that identifies the patent applicant in English

2.1.1 Data selection

Figure 2-3 illustrates the raw data that I downloaded from SIPO. The dataset contains the firm ID, which I needed to identify the unique name of the listed firms, the application number and the application date, which I used to calculate the year of the technological diversification, and the publication number, the publication date, and most importantly the IPC, which I used to calculate the technological diversification. In total there are 846,838 observations in my dataset.

Chapter 2 Data and Methodology

	id	appno	appdata	gongkaohao	gongkairi
1	000016	CN201510421226	2015.07.17	CN105005110A	2015.10.28
2	000016	CN201510380469	2015.07.02	CN104992552A	2015.10.21
3	000016	CN201510332014	2015.06.16	CN104935843A	2015.09.23
4	000016	CN201520394969	2015.06.09	CN204741516U	2015.11.04
5	000016	CN201520272685	2015.04.30	CN204658310U	2015.09.23
6	000016	CN201520242587	2015.04.21	CN204576025U	2015.08.19
7	000016	CN201510164960	2015.04.09	CN104796641A	2015.07.22
8	000016	CN201520210065	2015.04.09	CN204517984U	2015.07.29
9	000016	CN201520209767	2015.04.09	CN204517983U	2015.07.29
10	000016	CN201510162528	2015.04.08	CN104793398A	2015.07.22
11	000016	CN201510148606	2015.03.31	CN104811746A	2015.07.29
12	000016	CN201510143228	2015.03.30	CN104780375A	2015.07.15
13	000016	CN201510119080	2015.03.18	CN104768047A	2015.07.08
14	000016	CN201510119059	2015.03.18	CN104766567A	2015.07.08
15	000016	CN201510120671	2015.03.18	CN104766465A	2015.07.08
16	000016	CN201510122913	2015.03.18	CN104811636A	2015.07.29
17	000016	CN201520155358	2015.03.18	CN204518003U	2015.07.29
18	000016	CN201510108271	2015.03.12	CN104853188A	2015.08.19
19	000016	CN201520136853	2015.03.10	CN204517946U	2015.07.29
20	000016	CN201510100941	2015.03.09	CN104796650A	2015.07.22

Figure 2- 3 Raw data

	IPC
1	G02F1/13357; G02H6/00
2	H04N21/422; G08C23/04
3	H04N5/44; H04N5/63
4	H04N5/64
5	H25H27/00
6	G02F1/13357
7	H04N13/04; H04N5/44
8	H04N5/44; H04N13/04
9	H04N5/44; H04N13/04
10	G02F1/13357; F21Y101/02; F21V29/506
11	H04N21/2343; H04N19/30; H04N21/262
12	H04N19/146; H04N19/30
13	H04N21/443; H04N21/426
14	G09G3/34
15	G08C23/04
16	H04N5/64
17	H04R1/02
18	H04N19/103; H04N19/30; H04N19/147
19	H05K7/20; H04N5/64
20	H04N9/31; H04N5/74
21	H04N9/31; H04N5/74
22	H04N5/60; H04N21/439; H04N21/422
23	B65D85/68; B65D81/05
24	H04N5/44; H04N5/64
25	H04N5/64; H04N21/422; H04N5/44
26	H04R1/02; H04N5/64

Figure 2- 3 Raw data part 2

2.1.2 Data cleaning

In order to unpack the IPC data to construct technological diversification, I first needed to classify each patent into one of eight patent classifications (see Appendix A for more details). The first letter of the IPC indicates whether the patent belongs to one of eight classifications. As a result, I needed to extract the first letter in each patent's IPC. Below is the Stata code for the identification of the patent class.

```
gen patentA=regexpm(IPC, "^A")
gen patentB=regexpm(IPC, "^B")
gen patentC=regexpm(IPC, "^C")
gen patentD=regexpm(IPC, "^D")
gen patentE=regexpm(IPC, "^E")
gen patentF=regexpm(IPC, "^F")
gen patentG=regexpm(IPC, "^G")
gen patentH=regexpm(IPC, "^H")
```

Figure 2- 4 Extract patent IPC with Stata

Then I aggregated the patent application numbers by firms' ID and year of patent application (I also needed to unpack the year, month and day from the variable application date). In this PhD thesis, I used an entropy measurement to calculate the technological diversification. Most studies have debated the merits of this measurement. Jacquemin and Berry (1979) demonstrated that the entropy value is a more effective measurement of the degree of diversification. They compared diversification values using the Herfindahl index and entropy index and confirmed the validity of the entropy

measurement. The following empirical chapters all used this dataset to compute the construct and conduct empirical regression.

Stkcd	Reptdt1	classA	classB	classC	classD	classE	classF	classG	classH	totalpatent	diversity
2	2002	0	0	0	0	3	0	0	0	3	0
2	2004	1	0	0	0	11	0	0	0	12	.286836
2	2005	0	0	0	0	3	1	0	0	4	.5623351
2	2006	29	2	0	8	2	0	0	0	41	.8584574
2	2007	0	0	0	0	3	0	0	0	3	0
2	2008	0	1	0	0	29	0	0	0	30	.1461448
2	2009	0	0	0	0	3	0	0	0	3	0
2	2010	1	3	0	0	27	0	1	0	32	.5818787
2	2011	0	0	0	0	2	0	0	0	2	0
2	2012	0	0	0	0	5	0	0	0	5	0
2	2013	0	0	0	0	2	0	0	0	2	0
2	2014	0	0	0	0	2	0	0	0	2	0
2	2015	0	0	0	0	0	1	0	0	1	0
10	1995	0	1	0	0	0	0	0	0	1	0
10	2008	0	0	0	0	0	0	2	0	2	0
10	2009	0	9	0	0	0	0	0	0	9	0
10	2013	0	2	0	0	0	0	0	0	2	0
12	2007	0	0	6	0	0	0	0	2	8	.5623351
12	2008	0	1	4	0	0	0	3	0	8	.9743147
12	2009	0	4	22	0	0	0	6	3	35	1.052648
12	2010	0	5	16	0	1	0	1	0	23	.856859
12	2011	0	8	3	0	0	0	1	0	12	.8239592
12	2012	0	10	22	0	0	0	5	1	38	1.030324
12	2013	0	19	17	0	1	0	9	0	46	1.135511
12	2014	0	15	20	0	0	0	1	9	45	1.133098
12	2015	0	5	8	0	1	0	1	8	23	1.339048
14	1994	0	1	0	0	0	0	1	0	2	.6931472
14	1995	0	0	0	0	0	1	2	0	3	.6365142

Figure 2- 5 patent data used in this thesis

2.1.3 Data and a glance

Figure 2-6 illustrates the patent applications by year and class. As seen in figure 2-6, class B (Performing operations; Transporting) and class H (Electricity) have the most applications between 2003 and 2014. Applications increased from 2003, although there was a slight decrease in 2014.

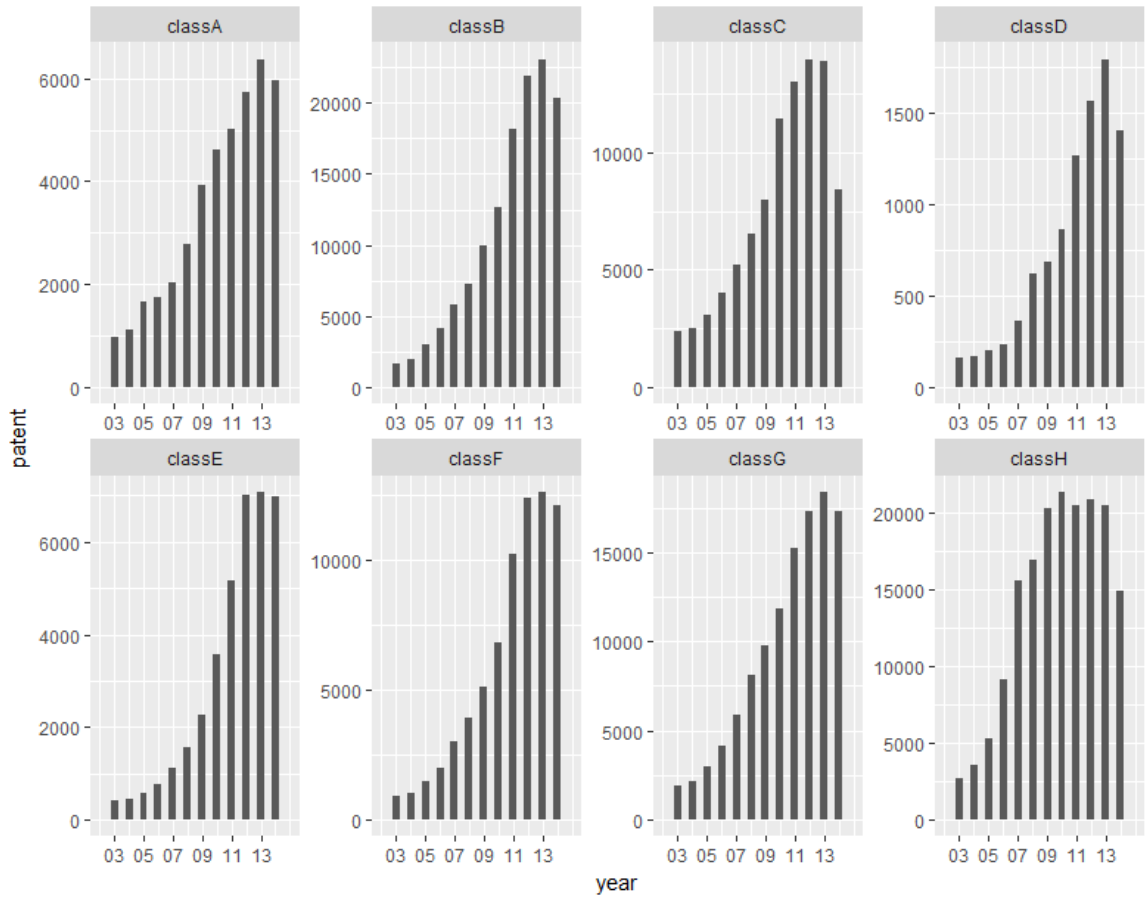


Figure 2- 6 Patent application by year and class

2.2 Economic Method

In the following empirical chapters, the dependent variable is the same- firm performance - which I measured as Tobin's Q. The reasons why I chose this construct are listed below. Following previous research on firm performance that used Tobin's Q (e.g. Blundell, Bond, Devereux, and Schiantarelli (1992); (Kor & Mahoney, 2005)) and the panel data nature of the sample, I adopted panel data regression in the following empirical chapters, with a Hausman test to choose between a fixed and random model. The tests all showed that a random panel data model fitted the sample and thus the fixed

model was rejected. The other reason that why I choose the random effect model is that my theoretical interest concerns the between-firm variance and there are time-invariant variables in our model which fixed model cannot estimate (Greene, 2003).

Chapter 3 Technological diversification and firm performance-A mechanical view

3.1 Introduction

Firms' technology capabilities not only drive regional and national growth, but are also considered an impetus for corporate growth (Lai, Chiu, & Liaw, 2010a). While product lifetimes have become shorter because of the accelerating pace of technological change, the fight against obsolescence is raising new and unprecedented challenges. To cope with these challenges, firms are investing more in research and development (R&D) in a broad range of technology domains. This increased investment in R&D can result in economies of scope, enhance absorptive capacity, reduce the risk involved in R&D, and create synergies across technologies (Chiu et al., 2008; Kim et al., 2016; Lai, Chiu, Liaw, & Lee, 2010b). More and more firms are therefore investing in research to diversify their technology portfolios.

The first decade of the twenty-first century witnessed a significant increase in research into technological diversification, which primarily focused on the relationship between technological diversification and firm performance (Lai & Weng, 2013; Miller, 2006). However, the empirical findings of prior studies have been mixed, which calls into question assumptions regarding the relationship between the two variables.

I suggest three reasons, from a mechanical view, that can explain the mixed findings regarding the technological diversification and firm performance relationship. First, the measures of diversification that previous studies have used are incomplete. The current operationalisation effectively measures ‘the breadth of a body of knowledge’, but ignores ‘how far a firm pursues links in the knowledge network’ (Miller, 2006), which can potentially result in inconsistent findings. That is to say, previous research concentrates only on exploration in regard to technological diversification but overlooks the exploitative activities associated with diversification. Understanding how exploitative technological diversification contributes to firm performance would not only provide a finer-grained view of exploitation in multiple technologies, but also seek to distinguish between two previously conflated forms of technological diversification, which may encourage further research on both perspectives. Second, the mixed results suggest that technological diversification only serves as an asset or resource for certain firms. Technological diversification serves as a zero-level capability in a high-tech firm, enabling it to get by, but in other firms, such diversification can serve as a first-order or higher-order capability, which could potentially drive performance (Winter, 2003). In this chapter, I define higher-order capabilities are those routines that allow firms to learn new routines which can confer firms with better performance (Adler, Goldoftas, & Levine, 1999). On the other hand, zero-level capabilities are those resources which can

only make firms survive in the industries (Winter, 2003). In this case, the capabilities may not necessarily contribute to firm performance as they are not unique and scarce resources (Barney, 1991). Different sample selection procedures thus also lead to different empirical results. Third, the inconsistencies in the studies' findings also prompt us to see the link between technological diversification and performance from a contingency perspective (Su, Guo, & Sun, 2017). While technological diversification is important to firms, it does not automatically lead to superior performance; rather, firms require certain resources to profit from technological diversification (Leten et al., 2007; Ravichandran, Liu, Han, & Hasan, 2009). Therefore, the relation between technological diversification and firm performance may be contingent on firms' resources.

As these three factors affect the primary assumptions that underlie the research, empirical findings based on these varying assumptions can hardly be compared; in addition, findings that do not measure technological diversification correctly can hardly be expected to produce an accurate estimation of the positive, negative, or curvilinear link between technological diversification and firm performance. To bridge this research gap, I adopt a three-step model to solve the problems. First, I construct a new measure of technological diversification, which captures how firms explore and exploit new technological opportunities; it combines how broad (breadth) a firm's technology

portfolio is, and how far (depth) a firm pursues each technology portfolio. Second, I try to investigate the different roles of technological diversification, since it can serve as a zero-level capability in high-tech firms or as a first- or higher-level capability in low-tech firms. Thus, I answer the second question: does technological diversification represent different kinds of capabilities in terms of promoting firms' performance? Third, I investigate the contingency effects of other firm assets. Complementary assets have been found to be pivotal in leveraging firms' research resources and technology portfolios, leading to superior performance (Rothaermel & Hill, 2005). This important factor, however, has not been considered in other studies on the impact of technological diversification on performance.

This chapter makes three contributions to the existing literature. First, I conceptualise and construct a technological diversification measurement that is more comprehensive than the measures used in previous studies. The model proposed in this chapter accounts for the exploitative perspective of technological diversification in addition to its variety (March, 1991). The majority of the research on technological diversification concentrates on the relative distribution of technology portfolios, while ignoring how well firms perform in each of these sectors. I test the technological diversification-firm performance relationship using a more comprehensive measurement of technological diversification, and subsequently, extrapolate its effects on firms' performance. Second,

I propose that another reason for the inconsistencies is that the order of technological diversification as a capability affects the relationship between technological diversification and firm performance. The literature mainly draws its theoretical grounding from the resource-based view (RBV), which classifies technological diversification as a firm capability (Chen et al., 2013). Although this is true, the literature does not differentiate between capabilities that can help a firm just get by financially or achieve superior performance (Collis, 1994). In this chapter, I try to incorporate this important concept into the research to explain the inconsistencies in studies on technological diversification. Finally, I test the effect of a new moderating factor – complementary assets – in the technological diversification-performance relationship. The role of complementary assets has long been recognised in facilitating R&D and technology capture (Swink & Nair, 2007). However, previous research only considers the roles of tangible complementary assets (e.g. Chiu et al. (2008) and Lai et al. (2010b)) while overlooking the effects of intangible complementary assets. In this chapter, I continue to take a contingency view on technological diversification, since it has previously been shown to be an effective way of explaining the technological diversification-performance relationship (Gao, Xie, & Zhou, 2015).

3.2 Theoretical background and hypothesis

3.2.1 Dimensions of technological diversification

Exploration and exploitation were originally developed in the context of organisational learning. However, since March (1991) publication, scholars have extended this conceptual framework to a variety of managerial contexts, including strategic management (He & Wong, 2004; Yang, Zheng, & Zhao, 2014), technology and innovation management (Martini, Laugen, Gastaldi, & Corso, 2013), organisational theory (O'Reilly & Tushman, 2008), international business (Stettner & Lavie, 2014) and managerial economics (Schrettle, Hinz, Scherrer -Rathje, & Friedli, 2014).

This chapter adopts the exploration-exploitation framework in regard to technological diversification. Explorative technological diversification refers to the extent to which firms search for possible technological domains and how well their technology portfolios are expanded. On the other hand, exploitative technological diversification refers to the extent to which firms utilise, refine and deepen their understanding of expanded technology portfolios, and thus build a comparative technological advantage. This discrimination is in line with the concept proposed by Miller (2006). He defines technological diversification as the “breadth of a body of knowledge and from how far a firm pursues in a knowledge network” (Miller, 2006: 606). This concept, on the one

hand, regards technological diversification as exploration, which can be understood as how firms engage in explorative activities to search for knowledge and reduce the risks of innovation. On the other hand, this concept also emphasises how firms adopt exploitative activities to refine their knowledge and deepen their understanding of expanded technology domains.

Explorative technological diversification has been studied extensively. The antecedents of explorative technological diversification have been found to be an organisation's inheritance, which includes its corporate strategy, competencies, firm culture (Tidd & Trewhella, 1997) and technological resources (Miller, 2004). The outcomes of explorative technological diversification, especially its financial implications, have also drawn much attention. However, the empirical findings of prior studies are mixed. Evidence of a positive linear relationship (Subramanian, Choi, Lee, & Hang, 2016), a negative relationship (Chakrabarti, Singh, & Mahmood, 2007), and a curvilinear relationship (Benito-Osorio et al., 2012; Huang & Chen, 2010; Leten et al., 2007) has been found in the literature. Moreover, the moderating effects of explorative technological diversification and firm performance have also been documented extensively.

On the other hand, technological diversification can also be understood as exploitation,

which relates to how well other competitors do in those expanded technologies (Belderbos, Faems, Leten, & Looy, 2010). Empirically, firms can be both versatile in multiple technologies and at the same time have a comparative advantage in these expanded fields. For example, after empirically analysing the technological trajectory of Canon since the 1990s, Watanabe et al. (2004) found that Canon had expanded its technology portfolios to 33 technological fields, and had a comparative advantage in several fields over its competitors (e.g. Sony and NEC). After investigating technology collaboration between firms and public research organisations (PROs), Angelo et al. (2017) acknowledged that firms with explorative technological diversification might “not be able to develop sufficient capabilities and understanding in each technology domain” (Angelo et al., 2017: 1251). Their work implies that exploitative activities in multiple technologies are necessary. Beyond that, theoretically, Montgomery (1994) asserts the importance of studying exploitative diversification, stating that “a firm with insignificant positions in a number of markets will not, in sum, have conglomerate power” (Montgomery, 1994: 165).

The two perspectives of technological diversification are based on different levels of research, one on the inter-firm level and the other on the intra-firm level (Belderbos et al. 2010). However, as mentioned in the introduction, although exploitative technological diversification has been found empirically and theoretically, the research

on its implications is limited.

3.2.2 Measurements of technological diversification

Many measures of technological diversification rely mostly on intra-firm characteristics. These include the entropy measure (Miller, 2004), the Herfindahl index (Lu & Beamish, 2004), the Blau index (Lahiri, 2010), counts of SIC codes (Sabherwal & Sabherwal, 2005) and the calculation of the distance between two vectors, as proposed by Gang, Choi, and Kim (2014). The measurements can be grouped into three main types: variety measurements, variety/balance measurements, and disparity measurements (Stirling, 2007).

Variety measurements involve counting the SIC codes of a firm's products in order to identify the number of categories covered by the firm's technology portfolio. This type of metric aims to establish how many different types of technologies a company owns: the greater the variety, the greater the technological diversification. However, this measure only considers the number of sectors in which a firm might be active, and ignores how well firms are performing in each category.

Variety/balance measurements include the entropy measure, the Herfindahl index, the Blau index, and their variations; these measurements track the number of categories as

well as technology patterns across categories. This type of metric aims to capture how much of each type of technology a firm has: the greater the variety/balance, the greater the technological diversification. This type of measure takes into account the number of categories in which a firm might be active as well as the relative distribution of technological activity across the categories (Zander, 1997); however, it ignores how well firms are performing in each category.

Disparity measurements involve calculating the distance between two vectors, and thus examining the differences in the types of technologies that firms possess. This type of measurement tries to capture the essence of technological diversification by calculating the distance between focal firms' technology portfolios and a reference based on some form of distance measure. The greater the disparity, the greater the technological diversification. This type of measurement is less commonly used in the literature, as it draws attention to the bilateral relationship between focal firms and reference points (Du et al., 2015). In addition, the measurement does not provide information on how well firms performed in each category.

The existing measurements of technological diversification all focus on explorative technological diversification while ignoring exploitation (Miller, 2006). Let us consider the entropy measure, the most popular metric for tracking technological diversification.

Suppose we have two firms, A and B, which have patents in two classes of technology, C and D. If firm A patented one technology in class C and one in class D, while firm B patented 100 in class C and 100 in class D, both firms are equally diversified at 0.69 based on entropy algorithms. Traditional measures do not discriminate between these two firms but see them as equally competitive. This is illustrated in Figure 3-1. In the technology market, however, a firm with 100 patents is more competitive than a firm with one patent. In other words, traditional measures only depict one part of technological diversification – the breadth of technological diversification. However, research on strategy management, which underscores how well a firm can perform in a certain field (Raisch, Birkinshaw, Probst, & Tushman, 2009) also reminds us that exploitation matters (Katila & Ahuja, 2002; Laursen & Salter, 2006).

In addition, traditional measures of technological diversification are sensitive to firms' portfolio composition, which can create ambiguities (Robins & Wiersema, 2003). A more comprehensive measure that accounts for both the exploration and exploitation of technological diversification is thus needed to better capture the role of technological diversification in promoting firms' competitive advantage (Morescalchi & Hardeman, 2015). Arguably, a comprehensive technological diversification measure should capture both how firms explore (technological diversification breadth) and how they exploit (technological diversification depth) new technological opportunities (Lai et al., 2010a).

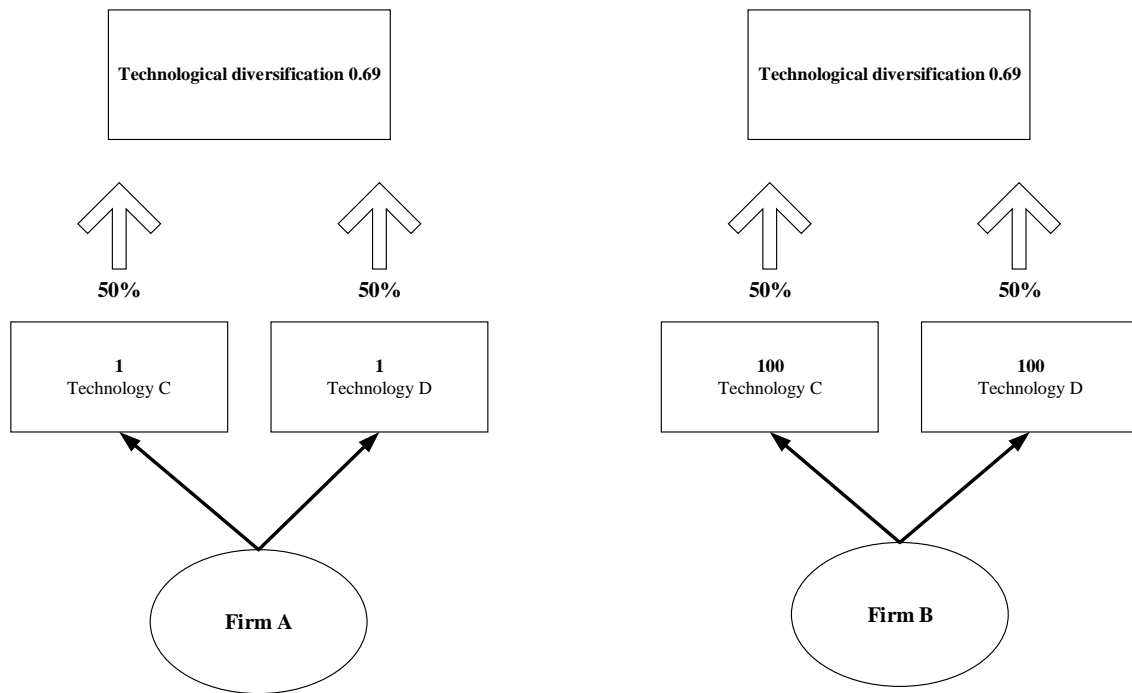


Figure 3- 1 Example of technological diversification measurement of entropy

3.2.3 Hypothesis

Following the definition given in this chapter, I argue that technological diversification that combines exploration and exploitation has a positive effect on firms' performance. Also, it should be noted that a firm can simultaneously widen and deepen its technological diversification (Gupta, Smith, & Shalley, 2006). That is, one dimension of technological diversification may help actualise the effect of the other, enabling the company to achieve economies of scale and scope (Cao, Gedajlovic, & Zhang, 2009).

First, explorative technological diversification can improve exploitative technological

diversification, which can help the company avail itself of certain economies of scale. In this sense, expansion to other technological domains enables firms to cultivate individual categories more extensively, which helps them to achieve the depth-cross-fertilise effect. For example, consider the case study of Canon provided by Watanabe et al. (2004). Between 1976 and 2000, Canon extended its technology portfolios, while subsequently gaining a competitive advantage in related domains. Watanabe et al. (2004) argue that this was perhaps because as firms invest in more technologies, they equip themselves with related and unrelated knowledge and resources, which leads to an increase in technological diversification depth. The accumulation of knowledge in other technology fields, the hiring of new employees, and increased collaboration between experts working in related fields all contribute to high technological diversification.

Similarly, high technological diversification exploitation can increase explorative technological diversification, which can enable firms to achieve certain economies of scope. This is mainly because exploitative technological diversification requires repeated investment in one category, and innovation in the same domain enables firms to develop a deeper understanding of related knowledge. Technological diversification depth can be described as an incremental innovation whereby an existing product or service is made better, faster or cheaper (Nelson & Winter, 1985). To achieve this goal, firms must recombine and reconfigure their existing knowledge and resources to

develop dynamic capabilities (Teece, 2007) that will help them find new routes to explore new markets and technologies (Ambrosini & Bowman, 2009). Moreover, the absorptive capacity literature describes this practice of learning new routines as a typical example of absorptive capacity, which enables firms to sense, seize and reconfigure technology opportunities, leading to a higher degree of technological diversification breadth (Zahra & George, 2002). Thus, I propose:

H3.1: Technological diversification combining exploration and exploitation has a positive effect on firms' performance.

Levels of technological diversification as an organisational capability

I have thus shown that technological diversification can increase firms' performance. However, as proposed by Collis (1994), the role of such organisational capabilities needs to be considered with some caveats. He argues that firms' capabilities are vulnerable to threats of erosion and substitution, and, above all, to being superseded by a higher-order capability of the 'learning to learn' variety (Collis, 1994). Organisational capabilities are not the 'ultimate' source of competitive advantage, and as Collis (1994) concludes, these capabilities are context dependent. Eisenhardt and Martin (2000) further extend this idea and propose that zero-level capabilities only permit firms to get by financially, whereas higher-level capabilities give firms certain advantages. In other

words, capabilities are locally defined. Eisenhardt and Martin (2000) provide an example of an R&D lab whose production of a new product is only a zero-level capability, which means that the lab can only survive alongside the competition. This shows that inconsistencies may also result from differences in sample selection procedures. If, for example, scholars select samples in which technological diversification serves as a higher-order capability, they are likely to identify a positive relationship between the two variables. In contrast, if the sample consists of firms for which technological diversification is a zero-level capability, no correlations are likely to exist between technological diversification and performance, and there may even be negative effects. If samples are made up of mixed firms, some with zero- and others with higher-order capabilities, non-linear or inverse U-shaped relationships are more likely.

This problem highlights why it is necessary for scholars to identify typical firm characteristics when considering the relation between technological diversification and performance. For high-tech firms competing in a highly competitive industry, technological diversification is only a 'how we earn a living now' capability. For example, aircraft engine manufacturers continue to diversify into multiple technologies because their competitors have the same kind of expertise (Prencipe, 2005). In such cases, technological diversification is a capability that enables firms only to meet the

minimum criterion of survival alongside the competition, making it a zero-level capability. In other words, technological diversification helps firms survive rather than make a profit.

Following this logic, I will explore the difference in the effect of technological diversification on firm performance in the cases of high-tech and low-tech firms. In high-tech firms, technological diversification is arguably less effective than in low-tech firms, as technological diversification only helps high-tech firms survive, while in low-tech firms it acts as a higher-order capability that drives firm performance. Thus:

H3.2: Technological diversification is more effective in promoting firms' performance in low-tech firms than in high-tech firms.

The roles of complementary assets

Teece (1986) was the first to propose the concept of complementary assets, defining them as resources or capabilities that allow firms to capture profits associated with technological innovation. Firms need complementary assets to profitably implement new technology strategies (Rothaermel, 2001). Without these complementary assets, new technologies and resource reconfigurations would be meaningless (Christmann, 2000). Teece (1986) identified three different kinds of complementary assets: first,

generic complementary assets, or general purpose assets that do not need to be tailored to the innovation in question; second, *specialised* complementary assets, where the innovation depends on the complementary asset; and third, *cospecialised* complementary assets, which involve bilateral dependence. Teece (1986) argues that specialised complementary assets are more important to firms since they cannot be easily replicated, while generic complementary assets can be purchased in the market. Even if other firms imitate a technology resource, they will not profit from it if they cannot replicate the complementary assets. Empirical evidence has established the role of complementary assets in assisting with exploitative alliances (Colombo, Grilli, & Piva, 2006), patenting propensity (Arora & Ceccagnoli, 2006), and information technology implementation (Powell & Dent-Micallef, 1997).

In the context of this study, the existence (or absence) of complementary assets can explain why empirical studies on technological diversification have reached different conclusions. Only firms with complementary assets can successfully commercialise innovative products and make profits from them. In this study, complementary assets are defined as the assets that a firm needs in order to make profits from multiple technology fields. Complementary assets, therefore, moderate the relationship between technological diversification and firm performance. In this chapter, I test typical specialised complementary assets – intangible complementary assets that cannot be

purchased in the market and facilitate the commercialisation of technology resources.

Thus:

H3.3: Complementary assets positively moderate the relationship between technological diversification and firm performance.

3.3Data and Method

3.3.1 Sample

The data used in this study come from two main sources. First, I accessed the data from the State Intellectual Property Office of the People's Republic of China (SIPO) on patents filed by Chinese listed firms. SIPO records information on every patent, including the application number, publication number, invention title, applicant name, priority number, abstract, agent, inventor, claims, International Patent Classification (IPC) number, publication date and application date. From this data, I used the IPC classification number to measure firms' technological diversification; the applicant name was used as a keyword to match the patent with listed firms, and the application date was used to identify the year.

I then accessed firms' financial data from the China Stock Market and Accounting Research (CSMAR) database. CSMAR is one of the largest databases of information

on Chinese stock markets and the financial statements of Chinese listed firms. In China, every listed firm has a stock ID that can be used to identify the company. The firm ID was used to match the financial data and the patent data downloaded from SIPO.

3.3.2. Measurements

Dependent variable

There are many measurements of firms' performance, and they can be mainly grouped into two types: accounting measures and market measures. Accounting measures include Return on Asset (ROA), Return on Equity (ROE), and Return on Sales (ROS). There are three main arguments against accounting-based measurements of firm performance. First, they are simply the reflection of past performance and are not forward-looking; second, they are not adjusted for risk; and finally, they will be distorted by temporary disequilibrium effects, tax laws, and accounting conventions (Bharadwaj, Bharadwaj, & Konsynski, 1999).

Scholars in organisational learning have argued that a company's technological trajectory can be characterised as path-dependent and will affect the firm's performance in the long run (Fai, 2003). In terms of technological diversification, I suggested that it may take years before firms can get the profit from this strategy. As a result, a forward-looking measurement of firms' performance rather than backwards-looking metrics such as ROA is needed to study the relationship between technological diversification

and firm performance.

Instead of using accounting-based measurements, scholars in innovation research have adopted market-based measurements to better capture firms' performance. Tobin's Q has been suggested to use in the literature by indicating its advantage in capturing firms' short-term performance as well as long-term performance (Jayachandran, Kalaighnam, & Eilert, 2013). As this performance measurement is forward-looking, risk-adjusted, and less susceptible to changes in accounting practices (Wernerfelt & Montgomery, 1988), providing a simple metric to operationalise both short- and long-term performance effects using a single performance variable (Kor & Mahoney, 2005). In a simulation study, Sauaia and Castro (2002) found that that company with a high performance exhibited a higher value for Tobin's q than those with a poor performance. In addition, Tobin's q demonstrates aspects of the companies' future tendencies that may better fit the situation of this study. Thus, I use *Tobin's Q* as the proxy of firm performance, which is defined as the market value of assets divided by the total assets of the firm. The equation is as follows:

$$Tobin's\ Q = \frac{MV}{TA} \quad \text{(equation 3-1)}$$

Where MV is the market value of firms. It is calculated as:

(Total shares -B Share) ×Closing price of A share + B Share × Closing price ×Exchange Rate. TA is the total assets disclosed in the balance sheet

Independent variable

In this chapter, the independent variable is technological diversification. To generate a more comprehensive metric to capture this variable, I construct separate measures to capture technological diversification depth and breadth and then combine them for a compound construct.

Explorative Technological diversification: This variable captures the number of fields in which a firm operates. Here, I use the mainstream entropy measurement proposed by Jacquemin and Berry (1979). This takes into account the number of technology fields in which a firm might be active, as well as the relative distribution of technological activity across these fields (Zander, 1997):

$$\text{Explorative TD} = \sum_{j=0}^n P_j \ln 1 / P_j \quad (\text{equation 3-2})$$

Where P_j in the present context represents the share of firms' patents in the j_{th} technology. In this chapter, I use the standard IPC classification system of patents, which contains eight major sections. Thus, P_j denotes the relative distribution of j_{th} technology in all eight major sections. The value of the entropy measure ranges between

zero and $\ln n$. A higher index of explorative technological diversification means that a firm has a broader range of technology portfolios, while a lower index indicates that a firm concentrates its resources on a narrower range of technologies.

Exploitative Technological diversification: This variable measures how well a firm performs in multiple fields. A firm with high technological diversification depth should have an advantage over its rivals. Thus, instead of computing this variable on the basis of firm data, this metric should set a reference point. I construct this measure as follows:

$$\text{Exploitative TD} = \sum_{j=0} \frac{X_{ij}}{\sum_j X_{ij}} \quad (\text{equation 3-3})$$

Where X_{ij} represents the firm i 's patent applications in class j . The relative proportion of the number of patents that a firm has in a technology reflects the comparative advantage of that firm in that technology field.

Following this logic, I construct a measure of technological diversification by multiplying exploitative and explorative technological diversification. This measure of overall technological diversification considers both the comparative technological strength in multiple technologies (depth) and how well firms expand into multiple technologies (breadth). This contributes to the literature by providing a meaningful

measure of technological diversification rather than focusing only on competence scattering.

Moderating variables

Types of firms: In this chapter, I differentiate between high-tech and low-tech firms to test H2. Previous studies on Chinese listed firms have differentiated between high-tech and low-tech firms based on survey methods, particularly the work done by scientific parks such as Zhongguancun Science Park in Beijing (Dai & Liu, 2009; Zhou & Xin, 2003), as well as scientific parks in other provinces (Xiao, 2011). In this chapter, I try to develop a criterion that can better differentiate between high-tech and low-tech Chinese listed firms. In 2001, the China Securities Regulatory Commission (CSRC) published ‘Guidelines for the Industry Classification of Listed Companies’,² which stated that firms in several industries are high-tech firms. These include firms operating in raw chemical materials and chemical products (C43); chemical fibres (C47); electronics (C5); instruments, meters, cultural, and clerical machinery (C78); pharmaceuticals (C8); and information technology (G). A binary variable is thus introduced here: 1 for high-tech firms and 0 for low-tech firms.

² Revised in 2012. In the 2012 version, a new industry code was constructed that was different from the 2001 version. However, CSMAR provides both codes for listed firms. I thus use the 2001 industry code to identify high- and low-tech firms.

Intangible Complementary assets(CA): According to Lai et al. (2010b), qualitative and quantitative research has confirmed that if a firm owns complementary assets that enable it to commercialise innovative resources and ideas, the firm has a competitive advantage. In this chapter, I explore the moderating role of intangible complementary assets in the technological diversification-performance relationship. Intangible complementary assets, such as brand value and human capital, help firms commercialise new products (Teece, 1998). These are hard to purchase in the market and difficult for rivals to imitate (Gardberg & Fombrun, 2006). Thus, according to Teece (1986), intangible complementary assets are specialised complementary assets. Using the previous formula (Chiu et al., 2008; Lai et al., 2010b), complementary assets are defined as follows:

$$\text{Complementary assets} = \frac{\text{Intangible assets}}{\text{Total assets}} \times \text{VAD ratio} \quad (\text{equation 3-4})$$

Intangible assets include complementary assets used during concept creation, commercialisation and distribution. In this chapter, intangible assets include brand value, copyright, rights to use urban land, and so on. To eliminate firm size effect, whereby larger firms may have more intangible assets than small firms, the total assets of firms are considered. The value-added ratio (VAD ratio) is also included to represent the extent to which complementary assets are specialised (Shih-Chang, Nien-Chi, &

Jieng-Bin, 2003). In this chapter, the VAD ratio is calculated by dividing the value added by the sales of the firm. In the Chinese context, the value added is calculated as the sum of the profit, wage expenses, depreciation, welfare expenses, interest and taxation.

The VAD ratio captures the firm's willingness to acquire technology and assets (Chiu et al., 2008). A high VAD ratio shows that firms have a higher propensity to utilise complementary assets to make profits (Lai et al., 2010b). Thus, following previous research (e.g., Chiu et al. (2008); Lai et al. (2010b)), I also add the VAD ratio to represent the degree of complementary asset specialisation.

Control variables

I control for a number of factors that might affect firm performance. At the firm level, the quality of corporate governance has been found to be effective in predicting firms' performance, and independent directors are believed to be an important mechanism in constraining large shareholders' control and ensuring independent and effective firm decisions (Higgs, 2003). I thus measure the independent directors (*Independent director*) as a fraction of the overall number of directors. Board size (*Board size*) denotes the availability of firms' access to resources and their ability to reduce uncertainty in the environment. With more people on the board, including non-executives, firms can obtain access to different resources through informal links, and this may affect their

performance (Pfeffer & Salancik, 1978). I use the total number of board members to measure this variable. I also include firm size (*Firm size*), which is measured by the natural log of the total assets. Firm age (Age) is deducting the current observation year from the year in which the firm was first listed on the stock market. Firms with different ages may have different cost structures, which may affect their performance. Leverage (*Leverage*) has been found to affect firm performance and is defined as total debt divided by the total assets. *ED* represents the volatility of changes in profitability within the industry that the focal firm is operating (Keats & Hitt, 1988). Following the work of Keats and Hitt (1988), I calculate the industry level ED through two steps. I first regress the industry profit growth rate with year serving as independent variables. Then I divide the standard error of the coefficient by the profit industry means as the measurement of environmental dynamism (Chen, Zeng, Lin, & Ma, 2017). The large the value, the higher the ED. *Environmental munificence (EM)* measures the annual growth rate of profit/sales in focal firms' industry (Keats & Hitt, 1988). I employ the same method used for constructing ED above. EM is measured as the regression coefficients weighted by profit industry mean that capture the growth rate of profits (Chen et al., 2017). The large the value, the higher the EM. To control for the time effect of policy influence or other unobserved variances associated with time in China's rapid transition process, I introduce year dummies for the period 2003 to 2014.

3.4 Results

Table 3-1 summarises the descriptive statistics and the correlations between all of the

variables in the analysis.

Table 3- 1 Descriptive statistics and correlations³

	Variable	Mean	SD	1	2	3	4	5	6	7	8
1	Tobin's Q	1.91	1.13	1							
2	TD	0.001	0.002	0.07	1						
3	Firm age	11.98	4.95	-0.22	-0.02	1					
4	Independent director	0.37	0.05	0.02	0.01	-0.04	1				
5	Board size	8.94	1.74	-0.16	0.01	0.06	-0.36	1			
6	Firm size	21.64	1.10	-0.46	-0.02	0.20	0.04	0.31	1		
7	leverage	0.38	0.22	-0.44	-0.03	0.19	-0.03	0.19	0.45	1	
8	ED	0.01	0.01	0.01	0.35	-0.08	0.02	0.09	0.14	0.08	1
9	EM	0.08	0.02	-0.18	0.12	0.07	0.05	0.09	0.24	0.22	0.36

Notes: Dummy variables are not included; All the variables that vary by year are lagged; Sample from 2003 to 2014

³ The definition and equation can be found at appendix B

Table 3-2 presents the statistical analysis results. We can see from Table 3-2 that all of the models have been reported using the Wald chi-square test. Model 1 is the base model and includes only the control variables. With the help of these four models, I can test hypotheses 1 and 2.

Table 3- 2 Regression results

DV: Tobin's Q	Model 1	Model 2	Model 3	Model 4
	Full Sample	Full Sample	Low tech	High tech
Controls				
Independent director	0.32** (1.97)	0.29* (1.90)	0.37** (2.09)	0.22* (1.89)
Board size	0.002 (0.20)	0.002 (0.21)	0.002 (0.20)	0.00 (0.03)
Firm size	-0.21*** (-24.83)	-0.20*** (-14.29)	-0.27*** (-13.98)	-0.31*** (-24.06)
Firm age	-0.02*** (-4.21)	-0.03*** (-3.79)	-0.09*** (-4.87)	-0.38*** (-2.90)
Leverage	-1.02*** (-10.92)	-1.87*** (-15.23)	-0.09* (-1.80)	-1.66*** (-27.36)
ED	7.21*** (9.07)	9.01*** (10.87)	6.29*** (4.03)	13.57*** (5.23)
EM	-4.09*** (-4.20)	-3.21 (-1.20)	-4.23*** (-3.21)	-5.21*** (-5.43)
Predictors				
TD		11.12** (2.12)	8.23** (2.37)	3.12 (1.32)
Constant	3.21*** (5.33)	7.25*** (10.47)	2.21*** (6.52)	10.23*** (8.29)
χ^2 p	0.00	0.00	0.00	0.00

- t statistics in parentheses, year dummy variables were included but are not shown in the table
- $p < 0.1$, $**p < 0.05$, $***p < 0.01$

Hypothesis 3.1 predicts that technological diversification is positively linked to firm performance. In Model 2, I find that the coefficient of technological diversification is positive and significant ($\beta = 11.12, p < 0.05$). This indicates that technological diversification has a positive effect on firm performance; thus, Hypothesis 1 is shown to be true. Hypothesis 2 predicts that technological diversification is more effective in driving performance in low-tech firms than in high-tech firms. Model 3 includes a sub-sample of low-tech firms, and I find the coefficient of technological diversification to be positive and significant at 8.23 ($p < 0.05$). Model 4 includes a sub-sample of high-tech firms, and I find that the coefficient of technological diversification is insignificant. The results indicate that the effect of technological diversification is more significant in low-tech firms than in high-tech firms. Thus, Hypothesis 2 is supported.

Table 3-3 presents the results of the tests for the moderating effects of complementary assets. To avoid multicollinearity and construct the interaction effects of technological diversification and complementary assets, I standardised both variables. In Model 2, I find that the interaction term of technological diversification complementary assets is negative ($\beta = -0.019, p < 0.1$) which indicating a negatively moderate role of complementary assets. I also illustrate the moderating effect of complementary assets in Figure 3-2. Overall, I find evidence that the positive effects of technological diversification are diluted when combined with the effect of intangible complementary

assets.

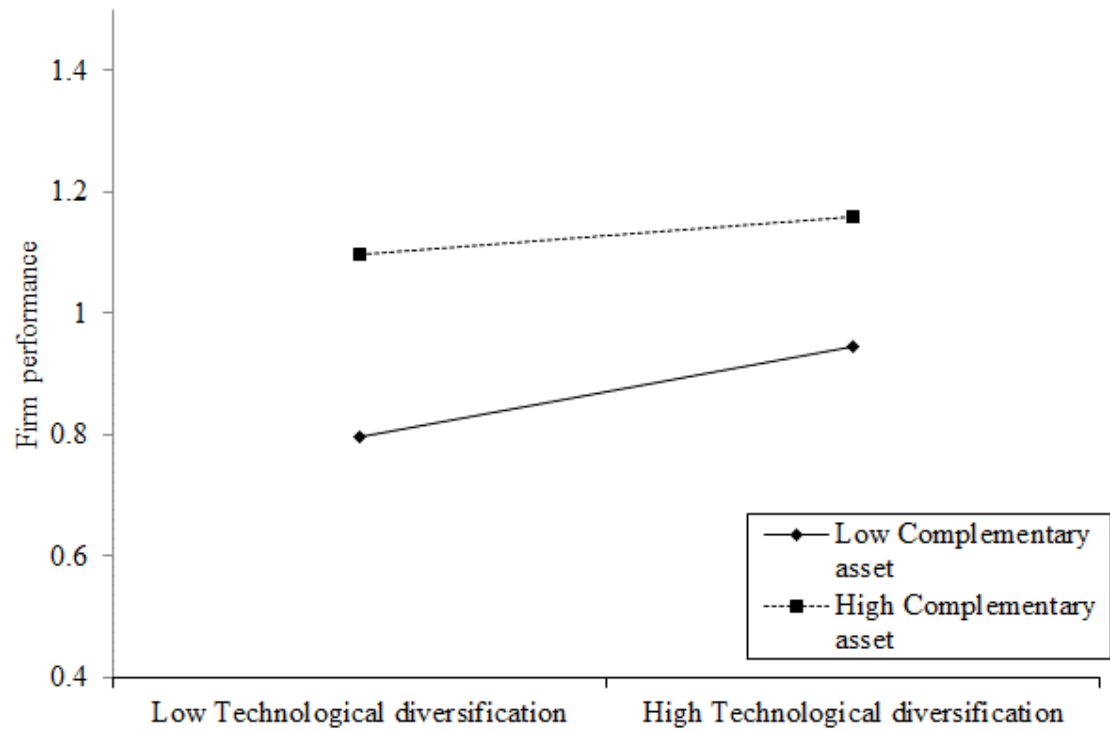


Figure 3- 2 Technological diversification's moderating effect on firm performance

Table 3- 3 Testing moderating effect of complementary assets

DV: Tobin's Q	Model 1	Model 2
Controls		
Independent director	0.29 [*] (1.90)	0.21 [*] (1.78)
Board size	0.002 (0.21)	0.002 (0.21)
Firm size	-0.20 ^{***} (-14.29)	-0.27 ^{***} (-10.28)
Firm age	-0.03 ^{***} (-3.79)	-0.01 ^{***} (-3.23)
Leverage	-1.87 ^{***} (-15.23)	-0.23 ^{**} (-2.21)
ED	9.01 ^{***} (10.87)	7.26 ^{**} (2.71)
EM	-3.21 (-1.20)	-2.31 ^{**} (-1.99)
Predictors		
TD	11.12 ^{**} (2.12)	10.21 ^{***} (3.09)
$TD \times CA$		-0.02 [*] (-1.78)
Constant	7.25 ^{***}	12.12 ^{***}

	(10.47)	(12.22)
χ^2 p	0.00	0.00

- t statistics in parentheses
- $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
- To avoid multicollinearity, technological diversification and complementary assets were standardised
- Year dummy variables were included but are not shown in the table.

3.5 Discussion and Conclusion

This chapter proposes and investigates three potential reasons for the inconsistencies, from the mechanical view, in the results of the studies on the relationship between technological diversification and firm performance. The first reason is the lack of a comprehensive measure to capture the essence of technological diversification; the second is the lack of attention paid to the order of technological diversification as a firm resource (capability); and, the third reason is the lack of attention paid to contingency factors. Based on the panel data on Chinese listed firms from 2003 to 2014, this paper empirically investigates the three reasons above, which indicates a statistically positive relationship between technological diversification and firm performance (measured as Tobin's Q). Although some previous studies have noted the importance of accounting for exploitative technological diversification (e.g., Miller (2006), no studies have used this dimension in empirical research. My measure of technological diversification accounts not only for explorative diversification, as in much of the literature, but also for its exploitation. This makes the results more easily translatable into real implications for managers.

In addition, my results confirm that technological diversification serves as different order capabilities in Chinese listed firms. I find that technological diversification serves

as a zero-level capability among high-tech firms, and that diversification, in this case, enables firms only to survive in a competitive environment. The findings can be explained through the mechanical view in terms of the RBV. Consider a situation that a high-tech firm is expanding its technologies, implying that it is fairly diversified. Suzuki and Kodama (2004) indicate that firms, especially high-tech firms in the same industry, have similar technology trajectories, which would indicate that their rivals have an equivalent level of technology diversification. According to RBV, this resource (technological diversification) is valuable, common, inimitable and non-substitutable (V_nRIN). Low-tech firms, in contrast, have varying levels of technology diversification, which makes it a valuable, rare, inimitable and non-substitutable resource (VRIN) (Barney, 1991). In conclusion, to deal with uncertain and rapidly developing new technologies, high-tech firms must quickly learn about technological opportunities to survive in the industry (Dodgson, 1991). Such actions, however, enable firms only to survive rather than to earn a profit.

This finding also has implications for firms in high-tech industries. Firms in these industries need to consider their diversification strategies as resources that make a living rather than some capabilities that can make better performance. If these firms want to profit from the diversification strategy, they should refer to explore and expand more in their technology portfolios or exploit in current multiple technologies to acquire the

resources that are non-substitutable (Barney, 2001).

In this chapter, I find that intangible complementary assets negatively moderate the relationship between technological diversification and firm performance. This implies that, with more intangible complementary assets, the effectiveness of technological diversification declines. This result is contrary to my expectation; however, it is not new in the literature. For example, Chiu et al. (2008) found that production and marketing complementary assets have negative moderating effects on firm performance; this indicates that complementary assets negatively moderate the relationship between external corporate venturing and technological scope. In my study, I believe the intangible complementary assets such as brand value and copyrights have a strong lock-in effect that may reduce the positive effects of diversification. For example, particular brand names are tailored to fit certain technologies and products, and these assets are difficult or expensive to leverage in the case of new products or technologies. In this sense, these intangible complementary assets do not help the company profit from technological diversification. Moreover, in the case of limited resources, firms with a licensing strategy that is focused on the in-house intellectual property may not be able to allocate enough resources to absorb other potential technology capabilities.

The findings of the negative moderating effects of intangible complementary assets

may also result from the measurement that used in this chapter. In this chapter, the measurement of intangible complementary assets consists of the land use right. However, in China, the use of land may prevent firms to explore the profit of technologies as the land use right is considered as more valuable, rare, inimitable and non-substitutable resource than the technologies. Thus, future research may resort to other operationalisation of intangible complementary assets to revisit this finding.

Limitations

This study is not without its limitations, and as a consequence, there are areas for future research. First, more measurements should be proposed to capture the depth of technological diversification. Although the measure I have developed to capture the depth of technological diversification is not sophisticated, I believe it can capture, to some degree, how far firms pursue technologies in different sectors. However, it is necessary to construct other indexes to calculate diversification depth in order to further test the validity of this study. Second, my research is also limited by the lack of finer-grained data showing how different types of diversification – related or unrelated diversification – affect firm performance. This is mainly because the IPC data does not contain any information similar to the four-digit and two-digit SIC codes used to identify related and unrelated diversification. I was limited by the data in constructing the measurements, and perhaps future studies could explore this promising research

area. Last but not least, this research is based on a single country and uses only a sample of Chinese listed firms. Replicating this study in a cross-country context or using a larger sample could be a promising way to validate my conclusions.

Chapter 4 Technological diversification and firm performance-An institutional view

4.1 Introduction

Technological diversification is a phenomenon that can hardly be ignored (Cantwell, Gambardella, & Granstrand, 2004). But, why do firms diversify and how do they benefit from multi-field technologies? Many believe that technological diversification is a valuable, rare, inimitable and non-substitutable (VRIN) resource that brings synergic effects and thus builds competitive advantage (Lai et al., 2010a; Lai et al., 2010b). From this perspective, managers can expect higher returns when they expand their technological portfolios.

While technological diversification research has advanced our understanding of managers' incentives to expand their technology portfolios, previous studies seldom consider the roles of institutions when firms decide to diversify and use the diversification to make a profit. Although every economic activity is embedded in society and institutions are never merely in the background (Scott, 2013), existing research on technological diversification largely depends on the mechanical approach and considers institutions as being 'backstage'. As 'rules of game' (North, 1990), institutions pushing factors are usually considered to be the background to the 'front

stage' (Meyer & Peng, 2016) and “*directly* determine what arrows a firm has in its quiver as it struggles to formulate and implement strategy and to create competitive advantage” (Ingram and Silverman, 2002: 20 emphasis added).

This neglect of social embeddedness limits the application of technological diversification and the precision of its predictions for two main reasons. First, institutional theorists suggest institutions such as norms, rules and regulations shape firms' decision-making without even noticing the existence of institutions (Deephouse & Suchman, 2008). Since this taken-for-grantedness has been taken for granted in technological diversification research, failure to identify the role of institutions can result in inconsistencies in the findings regarding technological diversification consequences. Second, rooted in open system logic (Scott & Davis, 2007), institutions' effect on the consequences of technological diversification may also be shaped by other environmental factors. Without considering this boundary effects, the institutional logic of technological diversification is also incomplete and may result in mixed findings.

My purpose is to explore how technological diversification conformity affects firm performance, from an institutional view, and its boundary conditions. Despite a growing consensus that “institutions matter” (Peng, 2013), institutional analysis of technological diversification remains in its infancy. The central argument here is that technological

diversification is a response to institutional pressure to acquire legitimacy, which defines a firm's success. Here, legitimacy is defined as "a generalised perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions" (Suchman, 1995, 574). Also, the boundary conditions of institutional analysis are far from clear and thus need further investigation. I offer new theoretical insights by considering environmental munificence and environmental dynamism as boundary conditions of this institutional logic.

This chapter takes the logic of appropriateness instead of the logic of consequentiality in this study. The institutional theory may serve as an antidote to the overly rationalist and technocratic perspective (Greenwood et al., 2008) and significantly influence the what used to think as market-based activities such as the scope of firms (Peng, Lee, & Wang, 2005). From the logic of consequentiality, technological diversification is considered 'atomic behaviour'. In this regard, organisations are 'atomic organisations' whose technologies and other activities are not clearly separated (Kamps & Pólos, 1999). However, in the real world and the context of this study, this setting is far from the reality as most organisations are complex (Thompson, 1967). Thus, considering technological diversification as 'atomic behaviour' and organisations as 'atomic organisations' no longer fits in the contemporary situation. In other words,

understanding the organisation as a social mechanism for achieving collective ends has become relatively neglected (Greenwood, Hinings, & Whetten, 2014).

The logic of appropriateness, by contrast, emphasises socially constituted and culturally framed rules and taken-for-granted norms (March & Olsen, 2008). In this sense, firms choose to expand their technology scope as a response to institutional pressure to become isomorphic; thus they become legitimated by key constituencies and gain access to resources (Greenwood et al., 2011). This furthers our understanding of technological diversification through a different logic to explain its effect on performance.

In addition, noting that the external environment matters (Hannan & Freeman, 1989; Lawrence & Lorsch, 1967), and that “technologies and environments are major sources of uncertainty for organisations” (Thompson, 1967: 13), I also test the environment boundary for technological diversification conformity. I believe this attempt will deepen our understanding of the effectiveness of institutions by integrating with contingencies of the external environment.

This chapter aims to make three contributions. First, I extend the diversification research by providing a unique lens through which to study technological

diversification. Past research takes a functionalist view of technological diversification as a rational profit-seeking behaviour undertaken by firms. However it has overlooked the fact that every firm action is also socially embedded and defined (Scott, 2013). I extend the technological diversification logic by providing a logic of appropriateness from an institutional view, instead of the logic of consequentiality that has been used in past research. I argue that it is the isomorphism of technological diversification patterns legitimated by key constituencies that profits firms rather than diversification as a firm resource. Because firms that look like each other can be regarded as having good standing in their class and are rewarded for their legitimacy, the technological diversifiers have incentives to copy other technological portfolios that are prevailing in their organisational field.

Second, I extend institutional theory by refining the boundary effects of institutions. I introduce two environmental dimensions: environmental munificence and environmental dynamism, as boundary conditions of technological diversification as an institutional logic. Institutional theorists have called for the identification of the boundaries of institutional theory (Suddaby, 2010). This chapter addresses this issue by identifying environmental munificence and environmental dynamism as two moderators to investigate the boundary conditions of technological diversification as an institution. In this sense, this study deepens our understanding and provides a finer-

grained model of theoretical prediction (Davis, 2015; Edwards, 2010).

Lastly, I draw attention back to the organisation. As noted by Greenwood et al. (2014): “institutional scholarship has become overly concerned with explaining institutions and institutional processes, notably at the level of the organisation field, rather than with using them to explain and understand organisations” (Greenwood, Hinings, & Whetten, 2014: 1206). I agree with this. This chapter refocuses how firms’ technological diversification as an institutional behaviour and get legitimate and accredited, thus profit from legitimacy. In this vein, I consider organisations as a phenomenon that needs to be researched and institutions as independent variables.

4.2 Theory and Hypothesis

4.2.1 Previous research on technological diversification

Previous studies have characterised technological diversification as a rational decision or strategy that can bring synergy to existing technology portfolios and/or as a resource that can be used to build competitive advantage (Corradini & De Propriis, 2015; Kim et al., 2016; Krammer, 2016). Firms’ successes are thus seen as a response to consistent criteria of technical efficiency. When the social embeddedness is considered, however, the many possible interpretations of firms’ behaviours and their socially constructed characters become obvious, casting doubt on the rationale of the diversification

objectives that the traditional, dominant paradigm puts forward (Boiral, 2003). That is to say, this perspective does not “recognise the potential influence of market actors ... about the sources or criteria of organisational efficiency” (Zajac and Westphal, 2004: 434). Although external pressures are rarely mentioned in explaining these ‘apparently rational’ motives, the implementation of strategies is essentially institutional pressure (Boiral, 2007). Seen from this perspective, previous research has considered that technological diversification behaviour tends to be rational. However, this practice is introduced more for reasons of conformity to the ‘rational myth’ than to project an image of rigour, objectivity, precision and control (Meyer & Rowan, 1977).

In this chapter, I highlight that technological diversification should be considered as embedded in a larger social context that confers resources and legitimacy, instead of merely considering it as an individual organisation’s rational activity. In this institutional view, technological diversification is more like a “rational myth” (Meyer & Rowan, 1977) than an effective strategy that is rationally designed by managers. As suggested by DiMaggio and Powell (1991) “institutionalism . . . comprises a *rejection* of rational-actor models often found in efficiency-based research” (DiMaggio and Powell, 1991: 8 emphasis added). This, however, does not mean to say that institutional constraints completely determine actions or that organisations are non-rational (DiMaggio, 1995; Oliver, 1997). Rather, “institutions set bounds on context-rationality

by restricting the opportunities and alternatives we receive and, thereby, increase the probability of certain types of behaviours” (Barley and Tolbert 1997: 94). It is through this context-rationality that organisations “appear to be rational” (Scott, 1983: 160).

Institutional models are most appropriate “where actors are unable either to recognise or rationally act upon their interests” (Friedland and Alford, 1991: 244), which is the case in this paper . According to institutional theorists, organisational actions are driven by the social jurisdiction-an expectation that organisations will achieve societal proven and acceptance (Scott, 2013). From this perspective, strategic activities are social and normatively defined because their motivations are expected to meet the legitimate standard of stakeholders (suppliers, customers, governments) who have the right to judge the rightness of the organisational value (Dacin, Oliver, & Roy, 2007). In other words, strategic and economic activities are social and normatively embedded into a larger context to seek proven for its action or legitimacy (Scott, 2008). This legitimacy-seeking behaviour follows a series of institutional norms or rules (North, 1990) to becomes isomorphic with their institutional environment (Dacin, 1997).

From this perspective, institutions are more than background conditions (Peng, Wang, & Jiang, 2008). Rather, the yields of technical benefits largely depend on the institutional environment of organisations (Peng, Sun, Pinkham, & Chen, 2009) and

legitimation is important for organisations to realise the technical and economic benefits (Peng, 2002). That is, “institutions *directly* determine what arrows a firm has in its quiver as it struggles to formulate and implement strategy and to create competitive advantage” (Ingram and Silverman, 2002: 20 emphasis added). What we learn here is that when considering technical or economic problems, we should remember that technical and economic activities are socially embedded and that we cannot ignore the institutions of the organisation, as they serve as an important facilitator in realising the potential of technical benefits (Wry, Lounsbury, & Glynn, 2011). This view may clarify why the rational view of technological diversification, as resources or capabilities, fails to provide consistent findings on the technological diversification-firm performance relationship.

4.2.2 Technological diversification-An institutional explanation

Institutional theorists believe that organisations’ survival depends on their conformity to the “rules of the game” (North, 1990), the humanly devised constraints that structure human interaction (Scott, 1987), rather than the efficiency of production (Levy & Egan, 2003). As Selznick (1996) noted, “perhaps the most significant” aspect of institutionalisation is infusion with value *beyond* the technical requirements of the task at hand (Selznick 1996: 217 emphasis added). In this respect, firms use technological diversification to manage their interdependence and gain power in the exchange network in order to improve organisational autonomy and legitimacy (Pfeffer, 1976).

Thus, firms that are willing to diversify do not intentionally seek profit; in fact in most cases, they lose benefits after becoming diversifiers (Pfeffer & Salancik, 1978). Firms choose to diversify when the external constraints cannot be absorbed or just to avoid turbulence due to uncertainties (Xia et al., 2014).

Institutions and institutional environment are composed of three “pillars”: the regulatory, cognitive and normative pillars (Kostova, Roth, & Dacin, 2008; Peng & Khoury, 2009). These three “pillars” are analogous to DiMaggio and Powell’s coercive, mimetic and normative isomorphic process (DiMaggio & Powell, 1983). In this institutional vein, technological diversification affects firms’ profit by building compliance or legitimacy and reducing uncertainty, mostly through the normative pillar (mimetic process) (Peng et al., 2009). Innovations or technological advances are a response to environmental turbulence and uncertainty (Calantone, Garcia, & Dröge, 2003). Uncertainties, however, are also a powerful force that encourages imitation (Oliver, 1991). When organisational technologies are poorly understood, or multi-technology management comes with uncertainty and cost (Leten et al., 2007), organisations may model themselves on other organisations (DiMaggio & Powell, 1983). In these circumstances, technological diversification or innovation can be accounted for by organisational modelling (Powell & DiMaggio, 1991). As described by Alchian (1950):

While there certainly are those who consciously innovate, there are those who, in their imperfect

attempts to imitate others, unconsciously innovate by unwittingly acquiring some unexpected or unsought unique attributes which under the prevailing circumstances prove partly responsible for the success. Others, in turn, will attempt to copy the uniqueness, and the innovation-imitation process continues.

From this institutional perspective, technological diversification is a way to mitigate institutional uncertainty in order to achieve a 'logic of appropriateness' within institutions, defined as socially constituted and culturally framed rules and norms (Peng, 2001; Schmidt, 2010). Thus, the effect of technological diversification, in an institutional manner, should be considered in terms of how homogeneity in a firm's technological portfolio can be achieved and whether this isomorphism affects firm performance. This research concept, compared with the rational decision view, focuses on the similarity of firms' technology base and how this resemblance can be regarded as a taken-for-granted 'game of rules', rather than its productive value in affecting resource deployment and further determining firms' success (Meyer & Rowan, 1977; Suddaby, 2010).

By applying the institutional logic of technological diversification, I argue that it is the isomorphism of their technological portfolio that affects firms' success and survival rather than technological diversification alone as an organisational attribute. From this point of departure, I believe that institutional pressure and legitimacy forces firms to look alike and not to be different, for fear that if they do, they will lack credibility

(Lawrence, Hardy, & Phillips, 2002). As the similarity of technology portfolio increases, a firm can be rewarded or gain accreditation through resources and assets from agencies of repute such as governments, industry associations or professionals (Dacin, Goodstein, & Scott, 2002). This will be explained in further detail below.

4.2.3 Hypothesis

I argue that conformity in technological diversification should bring firms performance benefits for two main reasons. First, conformity ensures greater resource commitment from stakeholders to improve firm performance. Diversification into new technological areas can be risky and costly, and often shows slower returns in the short-run (Kim et al., 2016). Key stakeholders may not, therefore, support or endorse firms' diversification objectives. As discussed above, a range of structures and strategies are institutionalised through an iterative isomorphic process that involves all stakeholders. These eventually become strategic norms and resemble the governance structures, institutional logics and cognitive consensus of others in the same organisational field (Suchman, 1995). To avoid potential legitimacy challenges by either internal or external stakeholders, firms adopt structures that are similar to those of their peers, thereby distracting attention away from controversial core activities that may otherwise not be fully supported by stakeholders. Moreover, firms' mimetic behaviours towards typical industry players can be seen as an industry recipe that can increase firms' chances of success and reduce the uncertainty regarding their actions in pursuit of technological

diversification (Pfeffer & Salancik, 1978). By aligning with the strategic norms, firms can legitimate their course of action and demonstrate their right to perform diversification in a predictable manner. Stakeholders comprehend and accept these actions and in turn increase the resource commitment that firms need to grow, such as capital from financial institutions, markets by consumers and regulators, and networks via suppliers (Zimmerman & Zeitz, 2002).

Second, conformity in regard to technological diversification increases partner participation and thus strengthens firm performance. Technological diversification is normally achieved through either internal development or external acquisition. However, firms are often constrained by their own resources and capability to enlarge their technological portfolios. They need to utilise external sources to substitute or complement internal R&D (Cassiman & Veugelers, 2006; Wang, Ning, & Chen, 2014). Collaborations with external bodies present unique co-ordination challenges because knowledge exchange beyond firm boundaries is often hindered by the tacit and firm-specific nature of knowledge (Ning & Li, 2016). In order to widen their collaborations and tap into more external knowledge sources, firms choose to standardise their technological operations around a common set of structured appearances and processes (Boiral, 2003). Firms with similar diversification structures can thus be easily understood and develop structural relationships with resource suppliers and coordinate

informal ties such as with trade associations and industry clusters to enlarge their pool of collaborators and alliance partners from different technological fields (Norman, Artz, & Martinez, 2007). This facilitates greater participation and knowledge exchange from all parties, thereby expanding firms' knowledge base and enabling them to realise the performance benefits of conformity (Dacin et al., 2007). Deviations from institutionalised structures lead to dissatisfied and confused collaborators, who may either reduce the quality and quantity of their participation or demand more resources to secure the same level of participation in knowledge exchange (Miller, Le Breton-Miller, & Lester, 2013). Moreover, although non-conformity strategies may allow firms to differentiate themselves in the marketplace and reduce competition, this benefit may be offset by the costs of legitimacy challenges and building complex relationships with collaborators (Deephouse & Suchman, 2008). Hence:

H4.1: Firms' conformity to their industry norms in regard to technological diversification is positively associated with firm performance.

The moderating effects of environmental munificence and dynamism

The above hypotheses are based on the idea that firms continuously interact with their environment and adjust their scope of technological diversification accordingly to survive and prosper. Now I consider the characteristics of firms' environment in order

to shed light on how these influence the relationship between technological diversification and performance. Extensive previous literature has indicated that the major contingency faced by firms is their environment and commonly follow the work of Dess and Beard (1984). Drawing on this insight, I focus on the moderating effects of two key characteristics of firms' environment: environmental dynamism and munificence.

Environmental dynamism refers to the extent of volatility and unpredictable change in a firm's external environment (Dess & Beard, 1984; Goll & Rasheed, 2004). In a highly dynamic environment, the uncertainty arising from, e.g. rapid changes in industrial structure, consumer tastes, technology and product lifecycles, is increased. As a result, firms may suffer from information processing burdens and are also no longer able to rely on their past experience in rational decision-making (Chandler, Honig, & Wiklund, 2005). They are therefore unable to adequately predict changes or future earnings and may be forced to delay major initiatives that require significant planning, such as R&D investment and technological diversification (Schilke, 2014).

As a result, stakeholders typically prefer short-term and less risky investments (Justin Tan & Litsschert, 1994). Information scarcity also causes them to compare how other organisations are approaching the situation (Angst, Agarwal, Sambamurthy, & Kelley,

2010; Felin & Zenger, 2009). Industrial norms, in this case, serve as a benchmark for them to evaluate performance and avoid high market risks. Firms with high conformity in regard to technological diversification can thus mitigate uncertainty and attract more resources, which allows them to continue to launch and grow new ventures to achieve growth (Anglin, McKenny, & Short, 2016). Similarly, these firms can provide a sense of predictability for their existing pool of collaborators and continuously benefit from flexibility in creating new knowledge and reducing its misfit in adapting to the dynamic environment (Wang, Ning, Li, & Prevezer, 2016). Hence:

H4.2: The higher the environmental dynamism, the stronger the relationship between firms' conformity in regard to technological diversification and performance.

Environmental munificence refers to the richness of the external resources that can support firms' sustainable growth (Dess & Beard, 1984). It indicates the extent of the external growth and expansion opportunities that are available in the environment. In a munificent environment, firms tend to adopt strategies and structures that enable them to assess and acquire a variety of resources, thereby capturing growth opportunities quickly (Gligor, Esmark, & Holcomb, 2015). Managers have more confidence and freedom to pursue long-term strategies (Barney, 1991). They are less constrained by the stakeholders due to reduced resource dependency in regard to exploring firms' networks,

working with collaborators and developing new structural relationships to seek and exploit new strategic paths (Brauer & Wiersema, 2012). Moreover, as a resource-rich environment encourages new entrants and intensifies competition, the main focus for firms is to explore new markets and technological opportunities. When adopting different strategies and deviating from the strategic norms, firms are more likely to gain a distinct position that brings them higher profits and reduces competition (Deephouse, 1996).

By contrast, in a less munificent and more hostile environment, where resources are scarce, firms pay greater attention to conserving their resources (Goll & Rasheed, 2004). While firms can rely on internal resources to buffer against the decline in external ones, the extent to which firms can pursue distinct value-adding activities is now constrained. They face trade-offs between exploring new technological areas and exploiting existing areas (Anglin et al., 2016). Withdrawal from low munificence industries is often viewed as a valid strategy to overcome resource constraints (Brauer & Wiersema, 2012). Moreover, as discussed earlier, firms may face more legitimacy challenges from stakeholders regarding their actions in deploying resources away from core technological areas. Thus, less strategic conformity decreases firm performance in a resource-scarce environment. Hence:

H4.3: The higher the environmental munificence, the weaker the relationship between firms' conformity in regard to technological diversification and performance.

Figure 4-1 illustrates the theoretical model used in this chapter

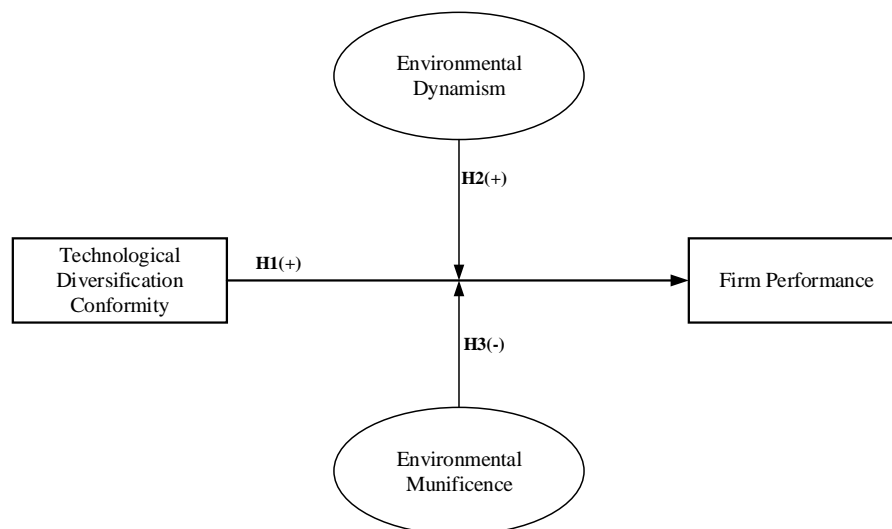


Figure 4- 1 Conceptual framework

4.3 Data and Method

4.3.1 Sample

To test the hypothesis, I constructed my sample from a combination of sources and manually collected firm data. First, I manually collected the patent data of Chinese listed firms from the State Intellectual Property Office of the People's Republic of China (SIPO) at <http://www.sipo.gov.cn/>. SIPO records information on every patent, including the application number, publication number, invention title, applicant, priority number,

abstract, agent, inventor, claims, IPC classification number, publication date and application date. The IPC classification number was used to measure firms' technological diversification, the applicant was used as the keyword to match the listed firms, and the application date was used to identify the year in order to calculate technological diversification.

Then I accessed each listed firm's financial data from the China Stock Market and Accounting Research (CSMAR) database. CSMAR contains all of the financial data collected from the annual reports of Chinese listed firms. In China, every listed firm has a stock ID that can be used to identify the company. Thus, this part of the data was used to match with the patent data accessed from SIPO using firms' ID as the matching word. This dataset has been found to be reliable and is used extensively in work regarding Chinese firms' governance performance (Zhang & Qu, 2016), outward foreign direct investment (Xia et al., 2014), social responsibility behaviours (Zeng, Xu, Yin, & Tam, 2012) and other related management fields.

4.3.2 Measurements

Dependent variable

There are many measurements of firms' performance, and they can be mainly grouped into two types: accounting measures and market measures. Accounting measures

include Return on Asset (ROA), Return on Equity (ROE), and Return on Sales (ROS). There are three main arguments against accounting-based measurements of firm performance. First, they are simply the reflection of past performance and are not forward-looking; second, they are not adjusted for risk; and finally, they will be distorted by temporary disequilibrium effects, tax laws, and accounting conventions (Bharadwaj et al., 1999).

Scholars in organisational learning have argued that a company's technological trajectory can be characterised as path-dependent and will affect the firm's performance in the long run (Fai, 2003). In terms of technological diversification, I suggested that it may take years before firms can get the profit from this strategy. As a result, a forward-looking measurement of firms' performance rather than backwards-looking metrics such as ROA is needed to study the relationship between technological diversification and firm performance.

Instead of using accounting-based measurements, scholars in innovation research have adopted market-based measurements to better capture firms' performance. Tobin's Q has been suggested to use in the literature by indicating its advantage in capturing firms' short-term performance as well as long-term performance (Jayachandran et al., 2013). As this performance measurement is forward-looking, risk-adjusted, and less susceptible to changes in accounting practices (Wernerfelt & Montgomery, 1988),

providing a simple metric to operationalise both short- and long-term performance effects using a single performance variable (Kor & Mahoney, 2005). In a simulation study, Sauaia and Castro (2002) found that that company with a high performance exhibited a higher value for Tobin's Q than those with a poor performance. In addition, Tobin's Q demonstrates aspects of the companies' future tendencies that may better fit the situation of this study. Thus, I use *Tobin's Q* as the proxy of firm performance, which is defined as the market value of assets divided by the total assets of the firm. The equation is as follows:

$$Tobin's\ Q = \frac{MV}{TA} \quad \text{(equation 4-1)}$$

Where MV is the market value of firms. It is calculated as:

(Total shares - B Share) × Closing price of A share + B Share × Closing price × Exchange Rate. TA is the total assets disclosed in the balance sheet

Independent variable

In this chapter, the independent variable is *technological diversification conformity* (*TD conformity*), which indicates the similarity in the focal firm's technology portfolio compared with the prevailing standard in the organisational field. This chapter conceptualises this as the technological distance between the focal firm and the industry average by calculating the extent to which their patents are included in the same technology classification. There are two main advantages of using patent classifications

to calculate *technological diversification conformity*. First, patents are classified according to the underlying technology by the Patent Office (Flor & Oltra, 2004), excluding endogenous interference. Second, compared with patents, end products have some limitations in terms of reflecting different technology capabilities. For example, similar products may have very dissimilar underlying technologies, making product measurement less reliable (Guan & Yan, 2016).

Following previous studies, I first produce each firm's technology portfolio and then construct the technological diversification proximity by computing the uncentred correlation of their patent distribution vectors across the technological classifications (Garcia-Vega, 2006; Guellec & van Pottelsberghe de la Potterie, 2001).

The technological diversification conformity between the m_{th} industry average and the i_{th} firm in the m_{th} industry is defined as:

$$P_{mi} = \frac{F_i F_m'}{((F_i F_i')(F_m F_m'))^{1/2}} \quad (\text{equation 4-2})$$

Where $F_i = (N_{i1}, \dots, N_{i2}, \dots, N_{ij})$ is the technological space of the i_{th} firm, and N_{ij} is the number of patents that the i_{th} firm holds in the technological category j ($j = (1, 2, \dots, 8)$). This vector is constructed using the distribution of the firm's patents

in the different technological areas. The distance varies between 0 and 1. When there is only one listed firm in a given industry, this value equals one; when the technological vectors are orthogonal, the measure is zero.

Moderating variables

Environmental dynamism (ED) and *environmental munificence (EM)* are the two environmental contextual variables. *ED* represents the volatility of changes in profitability within the industry that the focal firm is operating (Keats & Hitt, 1988). Following the work of Keats and Hitt (1988), I calculate the industry level ED through two steps. I first regress the industry profit growth rate with year serving as independent variables. Then I divide the standard error of the coefficient by the profit industry means as the measurement of environmental dynamism (Chen et al., 2017). The large the value, the higher the ED.

Environmental munificence (EM) measures the annual growth rate of profit/sales in focal firms' industry (Keats & Hitt, 1988). I employ the same method used for constructing ED above. EM is measured as the regression coefficients weighted by profit industry mean that capture the growth rate of profits (Chen et al., 2017). The large the value, the higher the EM.

Control variables

In this chapter, I control for a series of variables that contribute to firm performance. First, at the firm level, firm characteristics are introduced. I control for *firm size (Size)*, which is measured as the number of employees. Firm size may affect performance through economies of scope and scale. Firm age (*age*) is deducting the current observation year from the year in which the firm was first listed on the stock market. Firms of different ages may have different cost structures, which may affect their performance. Second, I control for several corporate governance variables; these variables may affect firm performance through mitigating the agency problems. At the firm level, the quality of corporate governance has been found to be effective in predicting firms' performance, and independent directors are believed to be an important mechanism in constraining large shareholders' control and ensuring independent and effective firm decisions (Higgs, 2003). I thus measure the independent directors (*Independent director*) as a fraction of the overall number of directors. Board size (*Board size*) denotes the availability of firms' access to resources and their ability to reduce uncertainty in the environment. With more people on the board, including non-executives, firms can obtain access to different resources through informal links, and this may affect their performance (Pfeffer & Salancik, 1978). I use the total number of board members to measure this variable.

Finally, to control for the time effect due to policy influence or other unobserved

variances associated with time in China's rapid transition process, I introduce *year dummies* for the period 2003 to 2014, with 2003 omitted as the reference year. To avoid a potential endogenous problem caused by correlations among the independent variables, I set the values for all of the control variables with a one-year lag (except for the dummy variables).

4.4 Results

Table 4-1 reports the descriptive statistics and correlations of all of the hypothesised and control variables. I examined the potential multicollinearity by both inspecting the value of the correlation coefficients among the independent variables and computing the variance inflation factors (VIFs). All of the correlation coefficients are below the 0.65 threshold. This suggests that the estimations are unlikely to be biased by multicollinearity issues (Tabachnick & Fidell, 2012). I further checked for potential multicollinearity by inspecting both the value of the correlation coefficients among the independent variables and computing the Variance Inflation Factors (VIF). All of the values are within an acceptable range, with a mean VIF value of 1.18 (Kleinbaum, Kupper, Nizam, & Muller, 2007).

Table 4- 1 Descriptive statistics and correlations⁴

	Variable	Mean	SD	1	2	3	4	5	6	7	8
1	Tobin's Q	1.91	1.13	1							
2	TD conformity	0.39	0.40	0.08	1						
3	Firm age	11.98	4.95	-0.22	-0.02	1					
4	Independent director	0.37	0.05	0.02	0.00	-0.04	1				
5	Board size	8.94	1.74	-0.16	0.00	0.06	-0.36	1			
6	Firm size	21.64	1.10	-0.46	-0.01	0.20	0.04	0.31	1		
7	leverage	0.38	0.22	-0.44	-0.03	0.19	-0.03	0.19	0.45	1	
8	ED	0.01	0.01	0.01	0.31	-0.08	0.02	0.09	0.14	0.08	1
9	EM	0.08	0.02	-0.18	0.11	0.07	0.05	0.09	0.24	0.22	0.36

Notes: Correlations > 0.03 in magnitudes are statistically significant at 0.1 level or higher; sample year from 2003 to 2014

⁴ The definition and equation can be found at appendix C

Table 4-2 shows the results of the regression models. Model 1 is the base model, which includes all of the control variables. Models 2 to 4 separately test the main effect of technological diversification conformity, the moderating effect of environmental munificence, and the moderating effect of environmental dynamism, respectively. The values of the χ^2 statistics are all significant at the 1% level, suggesting that all of the models are significant. The control variables in Model 1 indicate that these variables are crucial for improving firms' performance.

Hypothesis 4.1 predicts that firms' conformity in regard to technological diversification enhances firm performance. In model 2, the coefficient of TD conformity is positive and significant ($b = 0.39, p < 0.01$). Thus, hypothesis 1 is supported.

Hypothesis 4.2 predicts that the above conformity-performance relationship in regard to technological diversification is positively moderated by environmental dynamism. Model 3 indicates that the coefficient of TD conformity is positive and significant ($b = 0.31, p < 0.01$), while the interaction term $TD\ conformity \times ED$ is positive and significant in model 3 ($b = 10.63, p < 0.05$). These results are further confirmed in Figure 4-2. The figure shows that the degree of firms' conformity in regard to technological diversification increases with environmental dynamism. Thus, Hypothesis 4.2 is supported, indicating that there is a positive moderating effect of

environmental dynamism.

Hypothesis 4.3 predicts that the relationship between TD conformity and performance is negatively moderated by environmental munificence. In model 4, the effect of technological diversification conformity is still positive and significant, indicating that the finding of Hypothesis 1 is robust. The interaction term $TD\ conformity \times EM$ in model 4 is negative and significant ($b = -4.30, p < 0.05$). Figure 4-3 elaborates the moderating effect of environmental munificence. The effect decreases with environmental munificence, indicating a negative moderating role. Thus, Hypothesis 4.3 is supported.

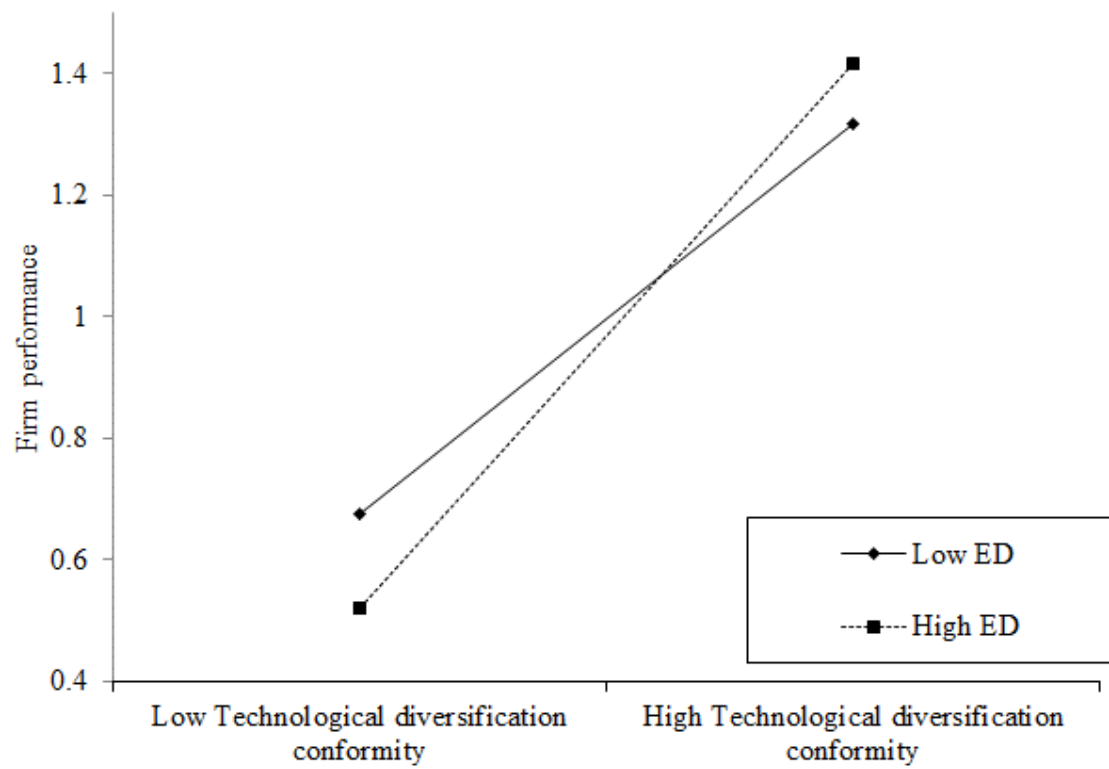


Figure 4- 2 Moderating effect of environmental dynamism

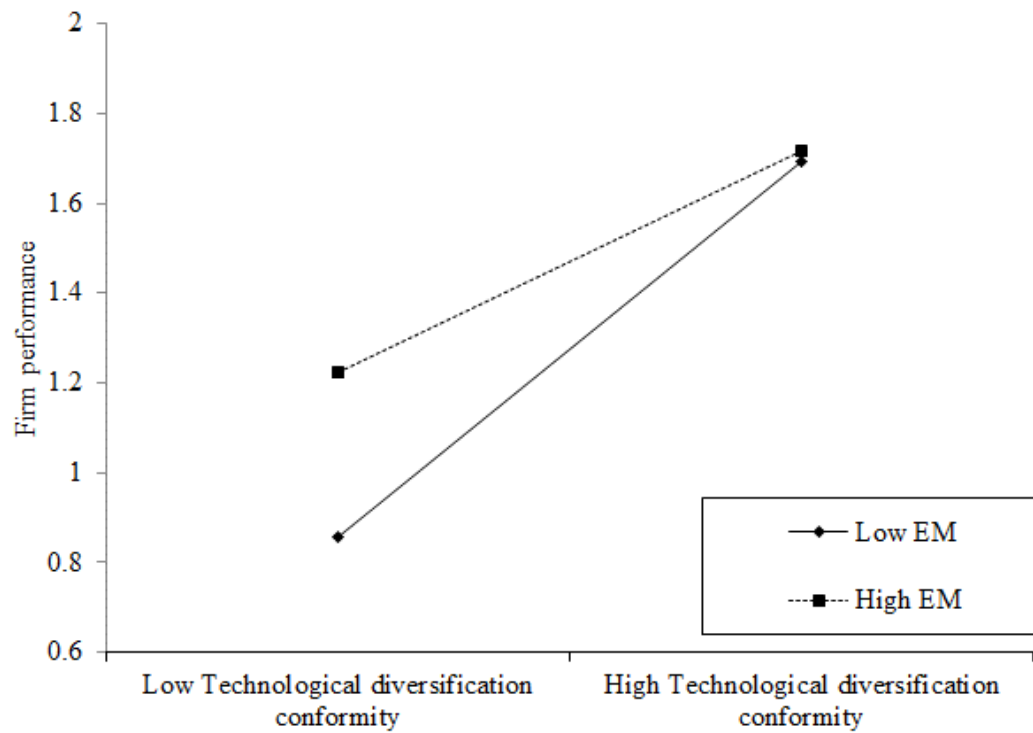


Figure 4- 3 Moderating effect of environmental munificence

Chapter 4 Technological diversification and firm performance-An institutional view

Table 4- 2 Estimation of the effects of technological diversification conformity and moderating effects of environmental munificence and dynamism

DV: Tobin's Q	Model 1	Model 2	Model 3	Model 4
Controls				
Independent director	0.32** (1.97)	0.47** (2.15)	0.43** (2.23)	0.39** (2.01)
Board size	0.002 (0.20)	0.003 (0.21)	0.002 (0.23)	0.001 (0.13)
Firm size	-0.21*** (-24.83)	-0.15*** (-10.42)	-0.13*** (-9.75)	-0.13*** (-9.99)
Firm age	-0.02*** (-4.21)	-0.02*** (-5.78)	-0.01*** (-5.62)	-0.01*** (-5.47)
Leverage	-1.02*** (-10.92)	-0.33** (-2.43)	-0.33*** (-2.58)	-0.33** (-2.07)
ED	7.21*** (9.07)	5.91*** (3.21)	-0.95 (-0.33)	4.89** (2.02)
EM	-4.09*** (-4.20)	-3.82*** (-4.14)	-2.50*** (-2.79)	-2.53** (-2.17)
Predictors				
TD conformity		0.39*** (13.32)	0.31*** (6.82)	0.66*** (5.03)
TD conformity × ED			10.63** (2.33)	
TD conformity × EM				-4.30** (-2.04)
Constant	3.21*** (5.33)	2.51*** (21.94)	2.32*** (20.62)	2.30*** (18.10)
χ^2 p	0.00	0.00	0.00	0.00

Notes: Unstandardised coefficients are reported, with *t* statistics in parentheses; DV: Dependent variable;

*** p<0.01, ** p<0.05, * p<0.1.

4.5 Discussion and Conclusion

This chapter has investigated the impact of organisational conformity in regard to technological diversification on performance. I further explored the role of industrial environments in moderating the relationship between conformity and the consequential firm performance. Although some early research explored the broad performance implications of technology diversification, we still know relatively little about how firms' conformity to strategic norms in regard to technological diversification patterns exerts an impact on performance. The source of firms' competitiveness in the discussion here is different from technological competence stemmed from resources or capability based on the resource-based view. Recent review studies have also suggested that there is a need to further examine firms' non-market strategies, such as conformity (Bascle, 2016).

To contribute to the understanding of firms' strategic behaviour in regard to conformity, this study first explores the process of firms' technological diversification. The institutionalists contend that firms' behaviours are largely driven by the external institutional environment, which can impose cognitive, normative and political influences and affect how firms acquire external resources (Greenwood, Díaz, Li, & Lorente, 2010). Organisational isomorphism, thus, can have an impact on firm performance (Deephouse & Suchman, 2008). Technological diversification is thus

unlikely to be entirely determined by firms' resources and capabilities. It can reflect firms' strategic decisions regarding the scope of their resource commitments (Deephouse, 1996). I suggest that the extent of diversification that firms choose will have performance implications. By aligning with the strategic norms and adopting the institutionalised organisational structure, I argue that firms can legitimate their actions in relation to diversification and enhance stakeholder acceptance and participation. This increases firms' external resource exchange, thereby resulting in performance benefits (Suchman, 1995). The findings also empirically elucidate that firms can benefit from diversifying their technology portfolio that is similar to the industry median. This echoes previous research in different contexts. For example, Miller et al. (2013) studied Fortune 1000 firms and found that strategic conformity in terms of production or operations strategy, product research and development, marketing, financial strategy, reinvestment policy and risk orientation is positively related to a return on assets, and Dacin et al. (2007) found that firms gain financial benefits through forming alliances and being similar to their industry peers.

Secondly, this study complements the existing literature by delineating the boundary conditions of conformity theory. I establish that environmental conditions play an important role in the link between firms' strategic conformity in regard to technological diversification and performance. In particular, the results enable us to comprehend the

environmental conditions under which firms generate competitive advantage by resembling their peers in the industry. In a highly dynamic environment where industries change rapidly, strategic conformity in regard to technological diversification enhances firm performance. This suggests that firms are better off aligning with the industrial norms to mitigate uncertainty and legitimate their diversification strategies as unpredictable changes in structures, lifecycles and consumer tastes. While in a resource munificent environment, firms with high conformity to the technological diversification pattern in the industry perform poorly. This result suggests that the positive performance benefits brought by strategic conformity are weakened by potential external expansion opportunities. Although firms are less constrained in terms of pursuing new technological paths, they face increasingly intensified competition as new entrants make inroads in the growing market. Overall, this study reduces the ambiguities regarding boundary conditions in conformity theory.

In terms of managerial implications, the most common business approach is to use the industrial median as a benchmark for business decision making (Miller et al., 2013). This finding suggests that managers can benefit from being strategically similar to the industry norms. Strategic conformity can be a source of competitive advantage; it may increase firms' chances of success. It may also help firms legitimate their strategic actions, especially in regard to pursuing long-term investments or developing

capabilities in risky and newer technological areas that are not fully supported by all of the stakeholders (Dacin, 1997). However, managers need to be aware that the extent of such performance benefits derived from conformity in regard to technological diversification is subject to the dynamism and munificence of the industrial environment. Both could alter the fabric of an industry. Firms benefit more from conformity in an uncertain environment while they gain fewer advantages in a resource abundant environment. These results provide valuable insights and serve as general guidance for firms in terms of adjusting the degree of their conformity in different environments.

This chapter is not without limitations, and future research could further explore and extend this line of inquiry. First, although this study empirically tests the relationship between conformity in regard to technological diversification and performance in different environmental settings, recent literature, such as the study by Zuckerman (2016), suggests that there is a need for firms to strike a balance between conformity and differentiation in order to achieve optimal distinctiveness. I have not considered this ‘strategic balance perspective’ in this chapter (Wæraas & Sataøen, 2015; Zhao et al., 2017). This chapter focuses, however, on providing further evidence to explain the benefits of strategic conformity in regard to technological diversification. Future research might want to expand this line of inquiry and take into account this theoretical

constraint. Secondly, this research is also limited by the availability of finer-grained data to reveal how the different types of diversification, namely related and unrelated diversification, affect firm performance. This is mainly because the IPC data does not contain any information, like four digit and two-digit SIC codes, to operationalise related and unrelated diversification (Sambharya, 2000). This study is limited by the data in terms of constructing measurements. Future studies could explore this promising research area. Thirdly, it is possible that some other environmental factors, such as organisational culture, market infrastructure, and the public relationship, might affect the conformity-performance relationship I have identified here. Future research could build on this study to further explore other contingency factors. Fourthly, this research is based on the single country empirical context of China and also a sample of Chinese listed firms. The replication of this study in a cross-country context or with a large sample could be a promising way to generalise the conclusions. Although this study is constrained by the limited data and methodology, it provides some useful insights into the way in which firms should approach technological diversification by considering the industrial and environmental contexts. Last but not least, in this paper, I consider the roles of dominate institution that make firms to imitate their peers and comply. However, recent theoretical advance also emphasised that there are multiple logics at work (Thornton & Ocasio, 2008). Though I do not consider this situation in this chapter, I would like to suggest that firms are embedded into multiple demands from different

stakeholders. However, this premise is not excluded from the roles of the dominant institution. In fact, though different logics work at the same time, the relative power of each institution is different. Thus, there may still one dominate institution that guide firms strategies (Lounsbury & Boxenbaum, 2013). Other institutions, on the other hand, may force firms to comply in a symbolic way, leaving it rather decoupled (Greenwood et al., 2011). I encourage future research to revisit this finding from the institutional logics view.

Chapter 5 Technological diversification and firm performance-An optimal distinctiveness view

5.1 Introduction

Scholars and practitioners are paying more attention to technological strategies because firms are suffering as a result of the increasing complexity of technology, the shortening of product cycles, and the fast-changing innovation environment (Wang et al., 2014). Among these strategies, technological diversification is a core interest for researchers of organisation and innovation (Bou-Wen, Chung-Jen, & Hsueh-Liang, 2006; Leten et al., 2007). Technological diversification has been seen as a way for firms to achieve economies of scope by sharing and recombining heterogeneous resources or capabilities, spreading innovation-related investment risks over several technological fields, and accessing multiple markets to increase overall yield (Ramaswamy, Purkayastha, & Petitt, 2017). Yet, research has tended to focus on strategic perspectives that emphasise that differentiation in terms of technological diversification can generate superior performance (Miller, 2006), rather than on the institutional perspective that conformity in regard to technological diversification patterns can confer legitimacy. This chapter offers a finer-grained view of technological strategy by arguing that firms should balance the differentiation and the conformity views of technological diversification to achieve better performance.

The existing research on technological diversification offers an incomplete view as it focused on differentiation through technological diversification. Such studies view technological diversification as a way for firms to differentiate themselves from their competitors, providing them with unexplored niches from which to profit. For example, Leten et al. (2007) view technological diversification as a means to reduce the transaction costs of purchasing technologies from the market. They believe that this strategy enables firms to outperform their competitors because firms with diversified portfolios are distinct and rare, and it is hard for competitors to imitate them (Miller, 2006).

However, these studies essentially focus on the strategic perspective of technological diversification – that distinctiveness can increase profits – and overlook the fact that it can be understood from an institutional perspective as conformity to industry receipt (Deephouse, 1999; Miller et al., 2013; Oliver, 1991). Understanding and combining these two perspectives of technological diversification can help us to better explain how and under what conditions a technological diversification strategy may benefit firms. It may also help to explain the inconclusive findings regarding how technological diversification impacts on firm performance.

Building on the strategic balance viewpoint (Deephouse, 1999; Zuckerman, 2016), I

argue that firms should strike a balance between differentiation and conformity in regard to technological diversification, which can generate abnormal rents for them. A singular focus on either differentiation or conformity could be detrimental to firms' performance. In other words, moderate technological diversification conformity can contribute to firm performance, while low or high conformity does not. A high level of technological diversification conformity will result in a firm facing severe competition and generating low rents, while a low level of technological diversification conformity will result in firm suffering from legitimacy challenges that will compromise its performance (Deephouse, 1999). This view can explain why previous studies on technological diversification have not reached a consensus on the technological diversification-performance relationship. Using data on Chinese listed firms from 2003 to 2014, this chapter empirically tests the aforementioned hypothesis. Moreover, I also investigate how the impact of moderate technological diversification may vary with differing firm characteristics, namely firm age and ownership.

This chapter seeks to make two contributions. First, it advances the research on technological diversification by combining the differentiation and conformity perspectives of technological diversification. It offers a finer-grained framework that can explain the so-far inconclusive findings on the relationship between technological diversification and firm performance. Second, it explores the boundary conditions of

how strategic balance may affect firm performance. Although strategic balance may contribute to firm performance, this relationship can be affected by organisational characteristics (Durand & Kremp, 2016). However, so far, no studies have attempted to investigate the boundary conditions of technological diversification conformity. This chapter tries to fill this gap by investigating how the effect of a moderate level of technological diversification conformity may change in different firm settings.

5.2 Theory and hypothesis

A strategic balance perspective of technological diversification

Firms are not just rational entities that voluntarily pursue economic goals; they are also embedded in a larger institutional context that is socially constructed (Westphal & Zajac, 2013; Zajac & Westphal, 2004). On the one hand, firms can be understood from the strategic view, which emphasises how self-interested firms strategically choose a response to differentiate their offerings from their peers in order to achieve better performance (Vracheva, Judge, & Madden, 2016). On the other hand, firms also need to adhere to industry-accepted rules in order to gain legitimacy (Deephouse & Suchman, 2008; Suchman, 1995). For example, if their strategic positioning is incongruent with the prevailing institutions, firms will suffer from legitimacy challenges and performance losses (Deephouse, Bundy, Tost, & Suchman, 2017). Thus, firms' strategies are influenced by both strategic and institutional forces. This study takes this

perspective by developing a strategic balance framework of technological diversification as an organisational response to both strategic and institutional demands.

Strategic view of technological diversification

The strategic view holds that firms with unique strategies face less competition, and can thus improve their performance (Pisano, 2017). This differentiation results from firms either maintaining a favourable position in their industry (Porter, 1980) or having valuable, rare, inimitable and non-substitutable resources, which confer on them a competitive advantage (Barney, 1991). In a perfect competition market, the economic rents equal zero, and firms enjoy less competition, or even a local monopoly when they find unexplored niches. The rents from this differentiation strategy depend on the speed with which competitors can imitate and successfully implement the same strategy, and the cost of doing so (Rajiv, Raj, & Arindam, 2014). When strategies are hard to imitate or expensive to implement, firms will enjoy a first-mover advantage if they exploit the benefits of differentiation. By contrast, when the cost of imitation is low, firms have to find new niches in order to remain different from their competitors. Otherwise, they will have to compete for limited resources in the same environment (Barney, 1991).

In this context, numerous studies have investigated the technological diversification-firm performance relationship from the strategic view. Technological diversification

can be understood as firms developing strategies to find new niches in the market and using these strategies to differentiate themselves from their peers, as the main purpose of technological diversification is to achieve synergies between different technologies (Kim et al., 2016). The new combination of technologies will enable firms to find new niches to exploit for profit. For example, Watanabe et al. (2004) have shown that Canon actively engages with multiple technologies in order to explore new combinations and innovations. Because these new combinations and innovations originate from the firm's unique technology routines, this technological diversification strategy makes imitation harder for competitors, thus giving the firm a longer time frame in which to derive profits from this strategy. Thus, from a strategic viewpoint, low-level technological diversification conformity will facilitate higher rents for firms.

Institutional view of technological diversification

Institutional theorists believe that a firm's strategy should be congruent with most of its competitors in order for the firm to gain legitimacy and achieve superior performance (Deephouse et al., 2017). In most industries, a firm-specific strategy is not necessary (Miller et al., 2013). Moreover, strategy selection involves uncertainty as firms can hardly predict customer and future market trends (Schilke, 2014). In such an uncertain environment, firms are likely to imitate the industry norm or the strategies of other successful firms (DiMaggio & Powell, 1983) to reduce uncertainty. Institutional

theorists argue that legitimacy is the key for firms to achieve success, and in turn, the key for legitimacy is simply to conform to industry norms (Deephouse & Suchman, 2008; Suchman, 1995) and take the industry receipt (Spender, 1989). Put simply, adopting strategies similar to those of others legitimates firms and increases their survival rate.

In this research context, the institutional view can explain how conformity in regard to technological diversification patterns will lead to firm performance. Innovating in technology, especially in multiple technologies, involves a high degree of uncertainty, as firms can guarantee neither the success of the innovation nor that customers will accept it in the future. In such circumstances, firms are likely to innovate and diversify like the majority of their competitors in the same industry. Zajac and Westphal (2004) found that the value of a firm is socially constructed and assessed by investors. Key constituents will try to understand a firm's behaviour and confer legitimacy by comparing the focal firm's strategies with that of their competitors (Zimmerman & Zeitz, 2002). If a firm's strategy is beyond the acceptance range and external constituents can hardly understand why the firm is engaging in such a strategy, they will label the firm a "misfit and idiosyncratic" (Reger & Huff, 1993). In such cases, firms will lose "easy access to resources, unrestricted access to markets and long-term survival" (Brown, 1998: 35). In short, firms with a high level of technological

diversification conformity will have superior performance.

A balanced, integrated approach

While it is theoretically possible that the strategic and institutional views will influence the mechanism between technological diversification and firm performance, I believe that by taking only one perspective, only a partial explanation of technological diversification can be provided. While the strategic view starts from the rational perspective that firms intentionally adopt strategies and pursue profits, the institutional view begins with a rejection of rationality as an explanation for organisational behaviour (Thornton & Ocasio, 2008). While firms are organisations with bounded rationality (Simon, 1991), both views would appear to have merit. On the one hand, the need for legitimacy leads firms to demonstrate their comparability with the standard offerings (such as providing technological diversification patterns similar to the industry recipe). Offerings that stand outside of the comparison are ignored and seen as “so many oranges in a competition among apples” (Zuckerman, 1999: 1401). On the other hand, competition drives firms to differentiate their offerings from those of their competitors to establish desirability. Zuckerman’s “candidate-audience interface” model suggests that firms’ behaviours need to satisfy the need for both differentiation and conformity to improve survival rates. Deephouse and subsequent studies have gone a step further, arguing that solving the tension between differentiation and conformity

is the key to firms' success. As a result, firms need to behave in a strategic, balanced way to improve their performance (Deephouse, 1999; Zhao et al., 2017; Zuckerman, 2016).

In sum, the integrated view emphasises the complementary nature of the strategic and institutional perspectives and that firms should seek optimal distinctiveness to improve their performance. Moreover, recent theoretical advances also indicate that the optimal level of conformity (distinctiveness) is contingent on a series of internal firm characteristics as well as external environmental factors (Askin & Mauskopf, 2017; Gehman & Grimes, 2016). Within this strategic balance framework, I will next advance and test the hypothesis on the impact of how a strategic balance of technological diversification will lead to firm performance and its boundary conditions.

Hypothesis

In a market with strong competition and institutional pressure, both differentiation and conformity should be important for firms to achieve success. From the strategic balance viewpoint, I expect firms with a moderate level of technological diversification conformity to have superior performance. When firms reach a high level of technological diversification conformity, they will not be affected by legitimacy challenges, but they will suffer from severe competition in terms of the number of

competitors with the same strategy. In this case, the rents of the strategy will equal zero.

The cost of severe competition outweighs the benefits of the legitimacy gains resulting from conforming to industry receipt. Thus, firms are less likely to benefit when conformity is high.

On the other hand, when firms choose a completely different strategy from those of their competitors, they still benefit very little from this differentiation. Although differentiation can provide firms with new niches, or even a monopoly position, such strategies cannot be understood by investors and other stakeholders. In this case, firms will suffer from legitimacy challenges when external constituents are reluctant to exchange resources with them. Firms are thus constrained if resources are expensive or have limited availability in the market (Deephouse, 1999). In this situation, the benefits of differentiation cannot compensate for the costs of losing legitimacy, and thus firms are less likely to benefit when strategic conformity is low.

I argue that firms will profit when their strategic conformity is moderate. This is also the case in relation to technological diversification. When a firm diversifies in ways that are completely unlike the approaches of its competitors (i.e. conformity is low), investors and customers can hardly understand or approve of the strategy and therefore are less likely to invest in or purchase products from the firm. When a firm achieves

moderate technological diversification conformity, it will enjoy the positive sides of both differentiation and conformity while suffering less than it would have from concentrating too much on either side. On the one hand, firms with moderate technological diversification conformity face reduced competition, which enables them to differentiate themselves from their competitors. On the other hand, such firms' technological diversification strategies do not fall beyond the acceptance range, which prevents them from being challenged by external constituents (Deephouse, 1999). By contrast, when technological diversification conformity is high, firms will face severe competition as their competitors are also providing the same technological products to customers. In a perfect market, customers will choose products randomly, making firms less likely to profit from being isomorphic. In conclusion, I expect that firms with moderate technological diversification conformity will have superior performance.

Hence:

H5.1: Technological diversification conformity exhibits a curvilinear (inverse U-shaped) relationship with firm performance. (There is a trade-off between the mechanical view and the institutional view of technological diversification)

Moderating effects of firm age and ownership

The above hypothesis is based on the idea that firms continuously interact with the

external environment to adjust their optimal level of technological diversification conformity. I argue that this adjustment depends on characteristics such as firm age (Oliver, 1997) and ownership (Li & Zhang, 2007). In this study, I also focus on the moderating effects of these two factors in relation to the impact of technological diversification conformity on firm performance.

In China, firms are significantly different depending on their ownership. It has been found that the relationship between the resource and market positions of state-owned enterprises (SOEs) and non-state-owned enterprises (NSOEs) are asymmetric in China. SOEs have been characterised as actors who “naturally have legitimacy and receive support or even protection from the government agencies that have founded them” (Li and Zhang, 2007: 794). Thus, the legitimacy stock of SOEs is more abundant than that of NSOEs. Compared with NSOEs, SOEs can bear more legitimacy changes. For example, Sherer and Lee (2002) investigated human resource management conformity in law firms and found that highly prestigious offices can be non-conformist, as they have more legitimacy stock available and are less sensitive to legitimacy changes.

In the case of technological diversification conformity, I predict that state ownership will negatively moderate the relationship between technological conformity and firm performance. On the one hand, NSOEs lack a stable legitimacy status and endorsements

from local government while enjoying lower agency costs, more effective administration processes, and a fast response to market change (Zhou, Gao, & Zhao, 2017), and thus the value of these firms is increased more quickly when they are legitimated through technological diversification conformity. SOEs, by contrast, are less likely to benefit from this increase in legitimacy, as they are already endorsed by local government and have an abundant legitimacy stock; thus, their legitimacy status is stable and not a concern in relation to their performance. On the other hand, the damage arising from over-conformity is also greater for NSOEs. In this case, firms' technological diversification patterns are similar to those of their competitors in the same industry; firms are thus constrained by a lack of distinctiveness rather than a lack of legitimacy. SOEs can get access to other important resources from local governments and agencies, as governments are large shareholders, which means that SOEs too big to fail (Peng, 2003). This makes the impact of over-conformity in terms of decreased performance less severe for SOEs than it is for NSOEs. Hence:

H5.2: State ownership negatively moderates the relationship between technological diversification conformity and firm performance, such that the curvilinear relationship between technological diversification conformity and firm performance is more pronounced (i.e., steeper) when firms are non-state-owned.

Firm age can also change the relationship between technological diversification conformity and firm performance. I predict that firm age will have a positive moderating role in the relationship between technological diversification conformity and firm performance. On the one hand, older firms with more ready-to-use resources at hand (such as trained employees, equipment, and informal personal ties) can more quickly and easily take advantage of increasing legitimacy to increase their value. Older firms will leverage their abundant ready-to-use resources and the image of legitimacy to attract new customers or find new niches in which to sell their products. By contrast, younger firms are less likely to benefit from the legitimacy increase from conformity as they are weaker in terms of absorptive capacity and production abilities, making it harder for them to use the image of legitimacy to attract customers. They are constrained by a lack of both credibility and the qualifications needed to provide products and services, in comparison to older firms (Zimmerman & Zeitz, 2002). Thus, increased legitimacy is less likely to solve all of their problems.

On the other hand, the damage arising from over-conformity is also greater for older firms. In this context, the advantages for older firms vanish and such firms are more likely to be constrained by path-dependent routines. Older firms are less likely to outperform younger firms because younger firms can be legitimated through adopting similar technological diversification strategies, while also enjoying a competitive

advantage in terms of having fewer sunk costs, a more effective administrative structure, and the ability to change their strategies at a faster rate. When technological diversification conformity is high, the routinised production procedures of older firms become a burden to these firms, whereas younger firms can more easily switch to different combinations of assets to meet the need for multiple technologies (Chiu et al., 2008). Hence:

H5.3: Firm age positively moderates the relationship between technological diversification conformity and firm performance, such that the curvilinear relationship between technological diversification conformity and firm performance is more pronounced (i.e., steeper) when firms are older.

Figure 5-1 conceptually illustrates the rationale behind this study, which aims to utilise the strategic balance framework in technological diversification research to capture the nature of technological diversification in a more comprehensive way. I also extend the research by investigating two internal boundary conditions, firm age and state ownership.

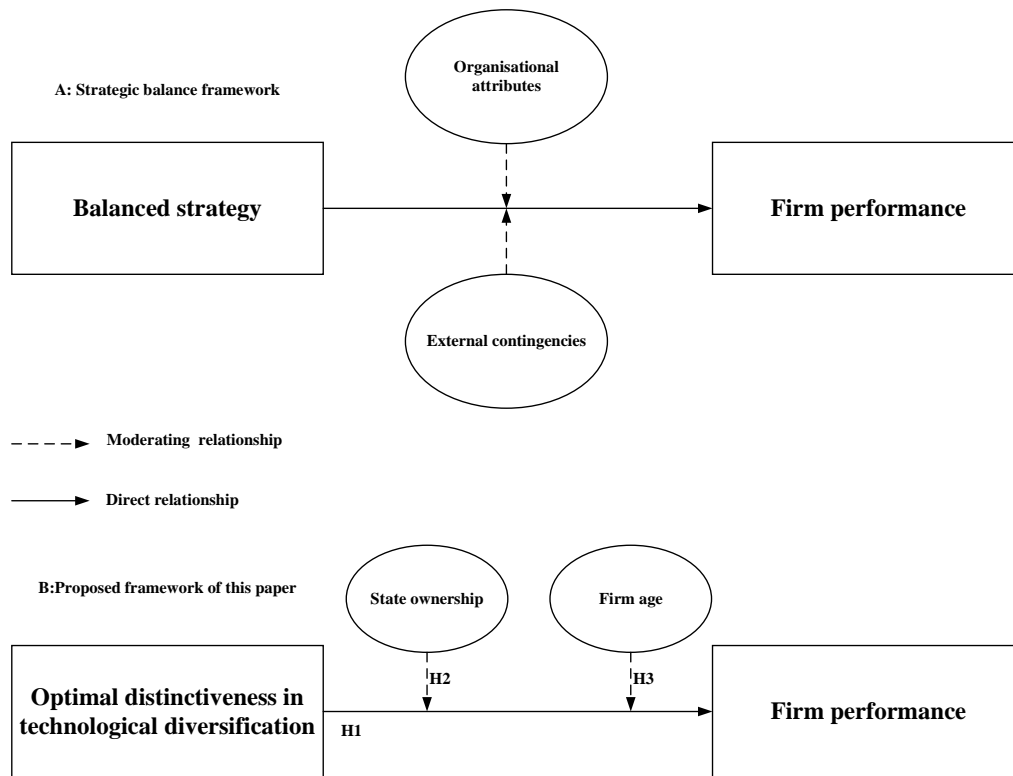


Figure 5- 1 Theoretical framework

5.3 Data and Method

The sample used in this study comprises the firms listed on the Shanghai and Shenzhen stock exchanges from 2003 to 2014. The sample was constructed from two independent sources: The China Stock Market and Accounting Research (CSMAR) database and the State Intellectual Property Office of the People’s Republic of China (SIPO). SIPO is the world’s largest patent office in terms of patent applications, having overtaken the Japanese Patent Office (JPO) in 2011 and the United States Patent and Trademark Office (USPTO) in 2012 (WIPO, 2012). SIPO records information for each patent, including the International Patent Classification (IPC), which is used to calculate

technological diversification conformity. CSMAR is one of the largest databases of Chinese publicly listed firms and a primary source of information on Chinese stock markets and the financial statements of China's listed firms, and has been adopted in various research settings, including in relation to corporate takeovers (Li & Qian, 2013) and corporate social responsibility (Marquis & Qian, 2014), among others.

Measures

Dependent variable: There are many measurements of firms' performance, and they can be mainly grouped into two types: accounting measures and market measures. Accounting measures include Return on Asset (ROA), Return on Equity (ROE), and Return on Sales (ROS). There are three main arguments against accounting-based measurements of firm performance. First, they are simply the reflection of past performance and are not forward-looking; second, they are not adjusted for risk; and finally, they will be distorted by temporary disequilibrium effects, tax laws, and accounting conventions (Bharadwaj et al., 1999).

Scholars in organisational learning have argued that a company's technological trajectory can be characterised as path-dependent and will affect the firm's performance in the long run (Fai, 2003). In terms of technological diversification, I suggested that it may take years before firms can get the profit from this strategy. As a result, a forward-

looking measurement of firms' performance rather than backwards-looking metrics such as ROA is needed to study the relationship between technological diversification and firm performance.

Instead of using accounting-based measurements, scholars in innovation research have adopted market-based measurements to better capture firms' performance. Tobin's Q has been suggested to use in the literature by indicating its advantage in capturing firms' short-term performance as well as long-term performance (Jayachandran et al., 2013). As this performance measurement is forward-looking, risk-adjusted, and less susceptible to changes in accounting practices (Wernerfelt & Montgomery, 1988), providing a simple metric to operationalise both short- and long-term performance effects using a single performance variable (Kor & Mahoney, 2005). In a simulation study, Sauaia and Castro (2002) found that that company with a high performance exhibited a higher value for Tobin's Q than those with a poor performance. In addition, Tobin's Q demonstrates aspects of the companies' future tendencies that may better fit the situation of this study. Thus, I use *Tobin's Q* as the proxy of firm performance, which is defined as the market value of assets divided by the total assets of the firm. The equation is as follows:

$$Tobin's\ Q = \frac{MV}{TA} \quad \text{(equation 5-1)}$$

Where MV is the market value of firms. It is calculated as:

(Total shares -B Share) ×Closing price of A share + B Share × Closing price ×Exchange Rate. TA is the total assets disclosed in the balance sheet.

Independent variable: The independent variable in this paper is technological diversification conformity (*TD conformity*). I construct this variable by measuring the proximity in technological portfolio between the focal firm and the industry median (Deephouse, 1999; Miller et al., 2013). Following the work of Jaffe (1986), I first calculate the focal firm's technology portfolio by counting the distribution of firms' patents in different technology classifications, and then compute the industry average. I then calculate the uncentred correlation of the patent distribution vectors of the focal firm and the industry median across different technological classifications as follows:

$$P_{mi} = \frac{F_i F_m'}{((F_i F_i')(F_m F_m'))^{1/2}} \quad (\text{equation 5-2})$$

Where $F_i = (N_{i1}, \dots, N_{ij})$ represents the technological portfolio of the i_{th} firm, and N_{ij} is the total number of patents that the i_{th} firm holds in the technological classification j ($j = (1, 2, \dots, 8)$) defined by the patent office; m denotes the industry average. The value of the proximity varies between 0 and 1. When the technological vectors of the firm and the industry average overlap, the value equals 1. When the vectors are orthogonal, the value is 0.

Moderating variables: Two moderating variables are included in this paper. Following previous research (Wang, Wong, & Xia, 2008), I measure *State ownership* as a dummy variable, which is equal to 1 if the firm is owned by the Chinese government and its agencies, and 0 if it is owned by private or other kinds of shareholders. Firm age (*age*) is calculated by deducting the current observation year from the year in which the firm was first listed on the stock market.

Control variables: I control for a number of factors that might affect firm performance. At the firm level, the quality of corporate governance has been found to be effective in predicting firms' performance, and independent directors are believed to be an important mechanism in constraining large shareholders' control and ensuring independent and effective firm decisions (Higgs, 2003). I thus measure the independent directors (*Independent director*) as a fraction of the overall number of directors. Board size (*Board size*) denotes the availability of firms' access to resources and their ability to reduce uncertainty in the environment. With more people on the board, including non-executives, firms can obtain access to different resources through informal links, and this may affect their performance (Pfeffer & Salancik, 1978). I use the total number of board members to measure this variable. I also include firm size (*Firm size*), which is measured by the natural log of the total assets. Leverage (*Leverage*) has been found

to affect firm performance and is defined as total debt divided by the total assets To control for the time effect of policy influence or other unobserved variances associated with time in China's rapid transition process, I introduce year dummies for the period 2003 to 2014.

At the industry level, the external environment affects firm performance through firms' risk sensing and strategy selection. Therefore, this study uses environmental munificence (*EM*) and environmental dynamism (*ED*) as control variables that have been found to affect firm performance (Chiu et al., 2008). Following the work of Dess and Beard (1984), I calculate the industry-level ED in two steps. I first regress the industry profit growth rate, with the year serving as the independent variable. Then I divide the standard error of the coefficient by the profit industry mean as the measurement of environmental dynamism (Chen et al., 2017). The larger the value, the higher the ED. Environmental munificence measures the annual growth rate of profit/sales in the focal firm's industry. I employ the same method used to construct ED above. EM is measured as the regression coefficient weighted by the profit industry mean, which captures the growth rate of profits (Chen et al., 2017). The larger the value, the higher the EM.

Methods

In order to reflect the result of the last two chapters, I use two different and interconnected approaches to examine the hypothesis. Specifically, I first multiply technological diversification, which includes the explorative and exploitative dimensions, and technological diversification conformity.

$$\text{Firm performance} = \alpha_i + \alpha_1 \text{technological diversification} \times \text{technological diversification conformity} + \alpha_2 \text{controls}$$

If α_1 is found to be negative and significant, I can confirm that there is a trade-off between strategic differentiation and conformity. Thus, Hypothesis 6.1 is supported.

Alternatively, I square technological diversification conformity; if an inverse U shaped relationship between technological diversification conformity and firm performance is observed, we can also confirm the trade-off between the mechanical and institutional views of technological diversification.

5.4 Results

Table 5-1 reports the descriptive statistics and correlations for each variable in this study. All of the correlation coefficients are below the 0.65 threshold. This suggests that the estimations are unlikely to be biased by multicollinearity issues (Tabachnick & Fidell,

2012). I also find that Tobin's Q is positively related to TD conformity, which provides preliminary evidence of a relationship between TD conformity and firm performance.

Table 5- 1 Descriptive statistics and correlations⁵

	Variable	Mean	SD	1	2	3	4	5	6	7	8	9
1	Tobin's Q	1.91	1.13	1								
2	TD conformity	0.39	0.40	0.08	1							
3	Firm age	11.98	4.95	-0.22	-0.02	1						
4	State ownership	0.39	0.49	-0.27	0.02	0.23	1					
5	Independent director	0.37	0.05	0.02	0.00	-0.04	-0.07	1				
6	Board size	8.94	1.74	-0.16	0.00	0.06	0.30	-0.36	1			
7	Firm size	21.64	1.10	-0.46	-0.01	0.20	0.41	0.04	0.31	1		
8	leverage	0.38	0.22	-0.44	-0.03	0.19	0.38	-0.03	0.19	0.45	1	
9	ED	0.01	0.01	0.01	0.31	-0.08	0.13	0.02	0.09	0.14	0.08	1
10	EM	0.08	0.02	-0.18	0.11	0.07	0.13	0.05	0.09	0.24	0.22	0.36

Notes: Correlations > 0.03 in magnitudes are statistically significant at 0.1 level or higher; sample year from 2003 to 2014

⁵ The equation and definition of each variable can be found on appendix D

Tests of hypotheses 1 and 3

Table 5-2 reports the regression model used to test the relationship between TD conformity and firm performance and the moderating effect of firm age. All three models are statistically significant. Model 1 is a baseline model that includes only the control variables. It suggests that independent directors, firm size, firm leverage, list exchanges, and environmental dynamism and munificence are related to firm performance. However, I do not find evidence that board size contributes to firm performance.

Hypothesis 5.1 predicted that there is a trade-off between the mechanical and institutional views of technological diversification. As discussed earlier, I provide two alternatives to measure this trade-off. Model 2(a) in Table 5-2 supports H1 with $b = 0.995$, $p < 0.01$ for TD conformity and $b = -0.938$, $p < 0.01$ for TD conformity square. In Model 3, the coefficients of TD conformity and TD conformity square are also significantly positive and negative respectively, providing a robust result. Moreover, in Model 2(b), the interaction between technological diversification and technological diversification conformity is negative and significant.

Hypothesis 5.3 predicted that firm age positively moderates the relationship between TD conformity and firm performance. The regression coefficient of the interaction

terms between TD conformity and firm age is positive and significant ($b = 0.019, p < 0.05$), and that of the interaction terms between TD conformity square and firm age is negative and significant ($b = -0.026, p < 0.1$). Thus, H5.3 is supported.

Table 5- 2 Results of regression analysis from the whole sample

DV: Tobin's Q	Model 1	Model 2a	Model 2b	Model 3
Controls				
Independent director	0.49** (2.07)	0.51** (2.15)	0.52** (2.23)	0.42* (1.81)
Board size	0.002 (0.20)	0.002 (0.27)	0.002 (0.20)	0.000 (0.03)
Firm size	-0.32*** (-24.83)	-0.32*** (-24.83)	-0.331*** (-26.15)	-0.31*** (-24.06)
Leverage	-1.41*** (-23.64)	-1.40*** (-23.55)	-1.48*** (-19.55)	-1.36*** (-22.86)
ED	19.00*** (10.02)	13.48*** (6.71)	10.23*** (4.23)	11.52*** (5.70)
EM	-5.60*** (-6.96)	-5.08*** (-6.32)	-5.31*** (-5.32)	-4.80*** (-5.98)
Predictors				
Firm age				-0.01*** (-5.95)
TD conformity \times TD			-0.23** (-2.09)	
TD conformity		0.99*** (8.44)		0.68*** (3.50)
(TD conformity) ²		-0.93*** (-7.49)		-0.57** (-2.57)
TD conformity \times Firm age				0.01** (2.05)
(TD conformity) ² \times Firm age				-0.02* (-1.84)
Constant	9.45*** (34.35)	9.32*** (33.99)	7.32*** (23.99)	9.42*** (34.35)
χ^2 p	0.00	0.00	0.00	0.00

Notes: *t* statistics in parentheses; **p* < 0.1, ***p* < 0.05, ****p* < 0.01; dummies were included but not reported.

Tests of hypothesis 2

In order to test the moderating effect of state ownership and following previous research (Gao, Shu, Jiang, Gao, & Page, 2017), I adopt subsample regression. There are two reasons for this. First, SOEs and NSOEs are different in nature, not in degree (Li & Zhang, 2007). Second, Cohen, Cohen, West, and Aiken (2002) suggest that subgroup regression is superior for testing the differences between regression coefficients in distinct groups, especially when the relationship is curvilinear. I then split the sample into two subgroups – SOEs and NSOEs – and adopt regression with each sample.

Table 5- 3 Results of regression analysis from the two subsamples

DV: Tobin's Q	NSOEs		SOEs		Bootstrap test
	Model 4	Model 5	Model 6	Model 7	
Controls					
Independent director	0.38 (1.15)	0.39 (1.20)	0.54 (1.51)	0.57 (1.59)	
Board size	0.005 (0.36)	0.006 (0.46)	0.005 (0.50)	0.005 (0.51)	
Firm size	-0.32*** (-14.80)	-0.32*** (-14.76)	-0.30*** (-18.29)	-0.30*** (-18.30)	
Leverage	-1.44*** (-17.40)	-1.42*** (-17.29)	-1.33*** (-14.64)	-1.32*** (-14.61)	
ED	25.03*** (8.95)	17.57*** (5.92)	12.54*** (4.83)	8.99*** (3.27)	
EM	-4.33*** (-3.38)	-3.30*** (-2.58)	-6.71** (-6.57)	-6.47*** (-6.31)	
Predictors					
TD conformity		1.14*** (7.37)		0.77*** (4.29)	0.369***
(TD conformity) ²		-1.07*** (-6.48)		-0.74*** (-3.90)	-0.323**
Constant	9.38*** (19.17)	9.17*** (18.85)	9.12*** (26.54)	9.05*** (26.33)	
χ^2 p	0.000	0.000	0.000	0.000	

Notes: *t* statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; dummies were included but not reported.

The results of the subgroup analysis shown in Table 5-3 were used to test H2. First, in NSOEs, the relationship between technological diversification conformity and firm performance is inverse U-shaped, $b = 1.143$, $p < 0.01$ for TD conformity and $b = -1.107$, $p < 0.01$ for TD conformity square. The relationship between technological diversification conformity and firm performance is also inverse U-shaped for SOEs, $b = 0.774$, $p < 0.01$ for TD conformity and $b = -0.747$, $p < 0.01$ for

TD conformity square. In order to test the differences in the corresponding regression coefficients in the two distinct subsamples, I adopt bootstrap test with 500 times resample. The results support H2 because the squared terms of TD conformity are significantly different for SOEs and NSOEs ($p < 0.05$).

The moderating results are illustrated graphically in Figures 5-2 and Figure 5-3. I find that the curve for NSOEs is steeper, indicating a negative moderating role of state ownership (Figure 5-2). Additionally, the curve for older firms is steeper, indicating a positive moderating role of firm age (Figure 5-3).

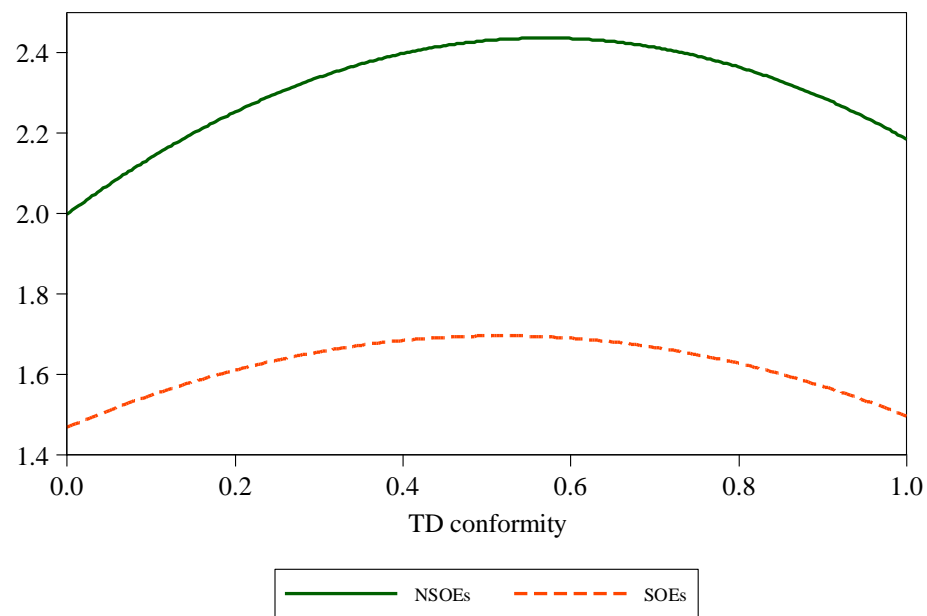


Figure 5- 2 Moderation effect of state ownership

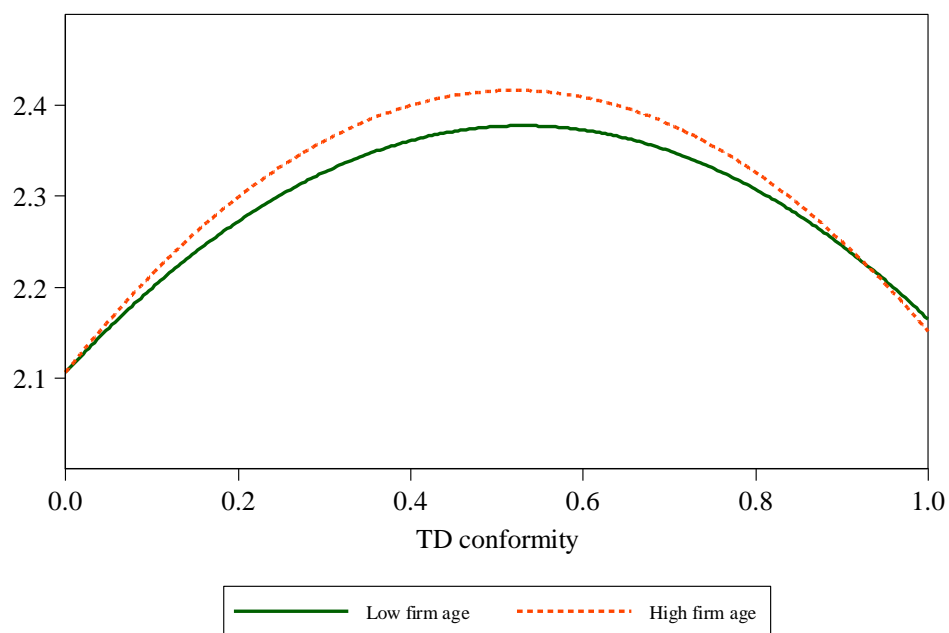


Figure 5- 3 Moderation effect of firm age

5.5 Discussions

Previous research on technological diversification is mostly based on the strategic view that perceives technological diversification as a strategy that helps firms to stand out from their competitors. However, recent theoretical advances in strategic balance argue that technological diversification can also be understood in terms of firms' conformity to industry norms, and that a balance between differentiation and conformity is the key to firms' success (Deephouse, 1999; Deephouse & Suchman, 2008). Drawing on the strategic view of technological diversification, this study focuses on how technological diversification conformity is related to firm performance in a non-linear way. I also investigate how this relationship may be altered depending on firms' characteristics in terms of state ownership and firm age. To the best of my knowledge, this is the first study to investigate, from a strategic balance perspective, how technological diversification affects firm performance.

Theoretical implications

This study makes several contributions to theory. It adds to the literature by offering a new perspective from which to understand technological diversification. Previous findings on technological diversification and firm performance are inconclusive. Most work has started from a strategic viewpoint to investigate how technological diversification affects firm performance. That is, such research takes technological

diversification as a strategy by which firms differentiate themselves from their competitors, and studies whether a higher (or lower) level of technological diversification can contribute to firm performance. This strategic perspective, however, overlooks the fact that firms' strategy can also be a response to institutional pressure to acquire legitimacy (Greenwood et al., 2008). This paper advances the technological diversification research by arguing that firms should reach a balance between being different to, and the same as, other firms, with the aim of being "as different as legitimately possible" (Deephouse, 1999: 147). This strategic, balanced view can partially explain how more or less technological diversification contributes to firm performance. External constituents should first compare firms with similar actors (i.e. categorization) to understand other firms' strategies (Zuckerman, 2016). Whether more or less diversification leads to greater profits also depends on competitors in the same industry. As a result, considering technological diversification only in a firm-specific way, without considering competitors' conditions, will hardly capture the mechanism through which technological diversification affects firm performance.

This study also found that the curvilinear pattern of technological diversification conformity does not remain the same across contexts. The effect of technological diversification conformity on firm performance also depends on firm characteristics such as firm age and state ownership. While previous studies on strategic balance (e.g.

Deephouse (1999) offer us insights into how the balance of differentiation and conformity affects firm performance, we still know little about how the optimal distinctiveness changes in response to various contingencies (Zhao et al., 2017). This paper advances the strategic balance research by identifying two contingencies: firm age and state ownership. Apart from knowing that reaching a balance between differentiation and conformity can benefit firms, we should also be aware that this relationship is not constant across all firms and that it depends on internal characteristics, such as firm age and ownership, as discussed in this study, as well as on external contingencies, such as public relationship and regional development, which need to be further investigated.

This study also adds to the literature by shedding light on technology strategies in emerging economies such as China. The advances in strategic balance have been theoretically proposed and empirically tested in the context of developed countries, where institutional infrastructures are well-established and stable. However, whether the findings based in developed regions still hold in developing countries where institutions are weak still needs to be investigated. Using a sample of listed Chinese firms, this study suggests that firms in developing countries also suffer from the trade-offs between differentiation and conformity. This study is also relevant in providing suggestions for rapid diversification for Chinese firms. These findings have

implications for Chinese firms in terms of how they can adopt technological diversification strategies to promote greater profit.

Practical implications

How to adopt technology strategies in such a way as to increase profit is a concern for all firms. I suggest that firms should be as legitimately different as possible. Firms should be aware that despite the benefits of strategic conformity, reaching a high level of conformity beyond the optimal point does not necessarily contribute to firm performance, and may even be detrimental to outcomes. As the findings suggest, diminishing returns are observed when firms' technological diversification conformity increases past an optimal point. Managers should continuously monitor the firm's technology patterns and performance. If unanticipated slowed growth or a decline in firm performance is observed, managers should try to decrease any trend towards greater distinctiveness of the firm's technology strategies. Moreover, the optimal distinctiveness (or isomorphism) will also depend on the firm's characteristics. The results suggest that NSOEs and older firms have a higher optimal level of conformity, and these firms' performance improves faster with greater conformity. However, the managers of these firms should also be alert to the fact that performance decline is also faster when firms pass the optimal level of distinctiveness.

Limitations and future research

This study is not without its limitations and, as a consequence, there are areas for future research. First, more boundary conditions should be identified. Although I have identified two contingencies, firm age and state ownership, more internal and external factors may change the optimal level of distinctiveness, which may have different implications for firms' strategies. More characteristics of firms, such as board diversity, personal ties, and political connections, should be included in the future. Contingencies such as customers' perceptions, public relationship, and institutional development also warrant further investigation. Second, this paper investigates technology strategy conformity – to be specific, technological diversification – but whether the findings can be generalised to other strategies, such as product diversification or corporate social engagement, still needs to be studied. Third, this research is also limited by the lack of availability of finer-grained data that could reveal how the different types of diversification conformity – namely, related and unrelated diversification – affect firm performance. This is mainly because the IPC data does not contain any information such as four-digit and two-digit Standard Industrial Classification (SIC) codes that could operationalise related and unrelated diversification (Sambharya, 2000). Last but not least, this research is based on the single-country empirical context of China and a sample of Chinese listed firms. The replication of this study in a cross-country context

or a larger sample would be a promising way to generalise the conclusions.

6.6 Conclusions

Starting from a strategic balance perspective, this study explores how technological diversification conformity affects firm performance, and how this relationship depends on firms' characteristics such as firm age and state ownership. My results show that technological diversification conformity exhibits a curvilinear (inverse U-shaped) relationship with firm performance. This relationship is weaker when firms are state-owned and when they are younger. This study advances the research through providing an alternative explanation of how technological diversification can contribute to firm performance.

Chapter 6 Closing Remarks

The previous three chapters address the technological diversification-firm performance relationship through three different but interconnected perspectives (i.e. the mechanical view, the institutional view and the optimal distinctiveness view). My results provide empirical evidence for all three perspectives. Thus, it is time for me to integrate the aforementioned three perspectives and also review the recent literature to build a framework that can suggest potential research leads. In this chapter, I will discuss some important topics that have not been addressed by the previous empirical chapters. Then I will review the recent literature on technological diversification and identify missing links (the mediation effect) that can explain how technological diversification can lead to firm performance.

6.1 Contributions, limitations and implications

Contributions

This thesis makes several theoretical contributions to the literature. From the mechanical view, I provide a theoretical unpacking of the two dimensions of technological diversification and a more comprehensive operationalisation of both dimensions. While previous research mainly concentrates on the explorative dimension of technological diversification, this thesis argues that we should also pay attention to the exploitative dimension that emphasises how deeply firms understand in each of the

technology domains. The more comprehensive understandings of technological diversification will help us know better how technological diversification will confer firms with competitive advantages to profit.

From an institutional view, this thesis argues that the institutions matter which is largely ignored in previous research. Previous research overlooks how firms' strategies such as diversification can also be influenced by institutions. In this regard, firms are affected by a dominated institution and try to imitate others to get legitimacy. However, whether technological diversification affects firm performance through an institutional way is less understood. I provide a theoretical explanation that how firms use technological diversification as a way to get legitimated and use this legitimacy to profit. In this way, this thesis provides another explanation to the technological diversification-firm performance relationship.

From the optimal distinctiveness view, if both the aforementioned views of technological diversification hold true, optimal distinctiveness view provides the combinations of both perspectives that offers a comprehensive view of how firms can profit for technological diversification consider both the environments and the individual firm. Previous studies mentioned less about the institutional explanations of technological diversification, even less when considered the balanced view. This view, however, can help understand not only why firms will engage diversification strategy but also what this strategy will be to make a better performance.

Limitations

Apart from the limitations that in the aforementioned empirical chapters, there are some limitations that I should emphasise to avoid overinterpret the findings. First, this thesis only considers one kind of diversification-technological diversification. However, I should admit that there are some other kinds of diversification such as product diversification, geographical diversification among others. Whether the findings hold true remain to be investigated in terms of other kinds of diversification.

Second, with the available data, I cannot unpack diversification into related and unrelated diversification. As a result, the findings cannot distinguish whether firms expand their technology portfolios related to their core capabilities or whether they expand their technological boundaries randomly. This is because I cannot measure the related and unrelated diversification as the IPC data lack the detailed information to be further unpacked into four and two-digit classes.

Third, the lack of consideration of another effect that may change the relationship between technological diversification and firm performance. In this thesis, I explored the boundary conditions (i.e. moderating effect) in terms of the external environments and the internal factors. However, recent studies (e.g. Li-Ying et al. (2016)) reminded us the mediation effect might also take place to affect the relationship. Though I do not empirically investigate the mediation effect, I will elaborate this effect and

methodology issues in next sections to encourage future research.

Managerial implications

Chapter 3 and 4 verifies the mechanical view and institutional view of technological diversification respectively. The chapter 5 goes further by combining both views. As a result, and at this point, I would strongly suggest managers should follow the findings from the optimal distinctiveness view. Firms should be “different enough from peer firms to be competitive, but similar enough to peers to be recognizable” (Zhao and colleagues, 2017: 93). Firms should be aware that, despite the benefits of strategic conformity, reaching a high level of conformity beyond the optimal point does not necessarily contribute to firm performance and may even be detrimental to outcomes.

As the findings suggest, diminishing returns are observed when firms’ technological diversification conformity increases past an optimal point. Managers should continuously monitor a firm’s technology patterns and performance. If unanticipated slowed growth or a decline in firm performance is observed, managers should try to counter any trend towards greater distinctiveness of the firm’s technology strategies. In terms of technological diversification, we suggest firms should first resort to a degree of technological diversification similarity compared with their peers to achieve legitimacy. This conformity is important, as it can demonstrate firms’ right to survive in the industry (Phillips & Zuckerman, 2001). They may imitate the most successful firms’ technological patterns in their industry to demonstrate they are the players on

the market (Phillips & Zuckerman, 2001). Then firms should decide an optimal level of differentiation (based on their organisational attributes such as firm age and state ownership) to outperform their competitors. In this way, firms can profit and be what Deephouse said “as different as legitimately possible” (Deephouse, 1999: 146).

6.2 An integrated perspective on technological diversification

I suggest that technological diversification can serve as the *hardcore* to meet the technological purpose of increasing efficiency, to mitigate the interdependence of external environments, and to lower the transaction costs from buying technologies. In addition, technological diversification can also serve as the *softcore* to meet the society and institutional purpose to maintain legitimacy and the right to survive. The optimal distinctiveness view, however, is a combination of the two. On the one hand, firms should be efficient in order to compete for limited resources in niches and gain a competitive advantage in that technology field. On the other hand, they should conform to industry norms and regulations to stay in a legitimate situation. To build an integrated framework, I will discuss some topics that have not been addressed in the previous empirical chapters.

Although I have discussed the importance of legitimacy, in terms of the definitions and consequences, in previous chapters, an important question that has not been addressed

earlier is: where does legitimacy come from? In other words, what confers organisational legitimacy?

In Deephouse et al. (2017) work, they refer to the entity that confers organisational legitimacy as the source that makes decisions that an organisation is legitimate or illegitimate. The first source of legitimacy is the state. For example, firms in China can be categorised generally into state-owned enterprises and non-state-owned enterprises. It has been found that the resources and market positions of state-owned enterprises (SOEs) and non-state-owned enterprises (NSOEs) are asymmetric in China. SOEs have been characterised as actors who “naturally have legitimacy and receive support or even protection from the government agencies that have founded them” (Li and Zhang, 2007: 794). Also, some organisations are routinely evaluated by government agencies. For example, in China, banks need to be certificated by the state to get a licence. Thus, these agencies have the right to accredit legitimacy to financial organisations.

Another source of legitimacy is public opinion. Public opinion can reflect the social norms and rules that accredit the organisation as being within the acceptable range. Bitektine and Haack (2015) give an interesting example of how public opinion can guide the purposes and targets of the *Academy of Management Review*. They suggest that the articles published in AMR are a reflection of the social norms and opinions

about which people are concerned. In this way, social opinion decides what it is right to publish.

The market can also be a legitimacy source. In the perfect market where information is symmetric, firms may use their product and service to compete with their peers. As a result, firms which can provide better services to their customers may earn the reputations (Thornton, Ocasio, & Lounsbury, 2012) and further get legitimated by market infrastructures such as customers watchdogs, rating agencies among others (Gao et al., 2017). For example, Phillips and Zuckerman (2001); Zuckerman (1999) proposed that analyst can categorise firms into different classes. While firms with a higher ranking are believed as legitimated, firms with middle-ranking have to conform to the rest of peers to get legitimate. They also suggested that firms with lowest rankings are supposed to be nonconformist as they are relatively stable in their positions regardless their actions.

The media can also be a source of legitimacy (Deephouse, 2000). First, the media can be a way to convey social opinions to the public and decide the right form of organisational behaviour (Deeds, Mang, & Frandsen, 2004; Lamin & Zaheer, 2012; Pollock & Rindova, 2003). An organisation can increase its survival rate by convincing the stakeholders that its competitors are not legitimate (Deephouse, 2000; Deephouse

& Carter, 2005; Pfeffer & Salancik, 1978). Two research streams have emerged in media study. Some have argued that the media is a social conveyor to public opinion, and later research has also documented that the media can shape public opinion. This is especially the case with the advances in big data and fast and more reliable information channels being available.

For example, the idea of the shared bike is spreading in China. At first, the shared bike was just a business innovation idea among small numbers of entrepreneurs and customers. However, the media has institutionalised the idea and followed the path of innovation, local validation, diffusion, and general validation (Johnson, Dowd, & Ridgeway, 2006). The innovative idea was first accepted by local customers, especially in some developed areas in China. Customers believe that they do not need to own a bike but rather can rent one instead as this can be more cost-efficient. At the start, the idea was validated locally. Then, the media helped to diffuse the new idea across the country. The national and local media advocated the benefits of shared bikes. Thus people nationwide came to accept the idea. At last, with more people accepting the idea, the shared bike became institutionalised and legitimated. In sum, the media can be a source of legitimacy.

Moreover, individuals can also be a source of legitimacy. Although early on, Zucker

(1977) studied how individuals can confer legitimacy, most research has been conducted at the collective level to see how organisations can confer legitimacy to another organisation. However, recent theoretical advances have already considered individuals as a source of legitimacy. Tost (2011) argued that “that individual-level legitimacy judgments are based on evaluations that fall along three dimensions (instrumental, relational, and moral)” (pp 686). In her article, Tost proposed three stages of legitimacy judgement: judgement formation, judgement use and judgement reassessment. Judgement formation and judgement reassessment are two judgement stages and judgement use, in her words, is an additional stage in which the opinions of the judgement can be utilised by individuals to see the validity of the judgement. In the judgement formation stage, an initial opinion is given by an individual through an evaluation. At this stage, individuals can use social criteria to decide whether an action was legitimate or illegitimate. She also proposes two modes of judgement formation, the evaluation mode, which refers to judgments of the overall legitimacy of an entity, constructed on the basis of evaluations of the entity along the instrumental, relational, and/or moral dimensions, and the passive mode, which refers to individuals either using validity cues as cognitive shortcuts to reach a legitimacy judgment or passively assuming the legitimacy of entities that conform to cultural expectations (Tost, 2011: 696). The use stage, on the other hand, carries the legitimacy judgement formed in the previous stage (legitimacy judgement). At this stage, individuals use the judgement to

guide an entity's behaviours. Individuals support organisations that are characterised as legitimate and boycott whose images are illegitimate. In the last stage, the judgement assessment stage, the legitimacy of the entity is re-evaluated. At this stage, individuals can use the feedback from the judgement using the stage to reassess the legitimacy status of the entity. As a result, "in the reassessment stage the evaluative mode predominates, and individuals engage in active attempts to evaluate the entity along the dimensions of instrumental, relational, and/or moral legitimacy, which once again drive judgments of generalised legitimacy" (Tost, 2011: 699).

Recently, Bitektine and Haack (2015) have refined the legitimacy model and proposed the micro and macro foundations of legitimacy. In terms of the micro-foundation, they specify that how individuals judge an entity can be a source of legitimacy. In their theory, they call the individuals who judge and confer legitimacy evaluators. Evaluators make their own decisions about the social acceptance of an organisation based on its social, political, and economic outcomes. Specifically, they argue that at an individual-level, legitimacy comes from propriety, which refers to an evaluator's approval of the organisation, its actions, or its practices as desirable and appropriate (Bitektine & Haack, 2015; Johnson et al., 2006). Propriety is thus an individual perception of social judgement and acceptance. They also propose validity at the collective level, which refers to "the extent to which there appears to be a general consensus within a

collectivity that the entity is appropriate for its social context” (Tost, 2011:689).

Individual-level propriety can also form collective level validity, which can confer legitimacy. In conclusion, individuals can also confer legitimacy on organisations.

6.3 Missing link between technological diversification and firm performance

In previous chapters, I have discussed the moderating effect of the technological diversification- firm performance relationship. However, recent literature has also suggested that the link between firms’ strategies and firms’ performance is not a black box, but rather is mediated by the typical firm and environmental characteristics (Li-Ying et al., 2016). In the following sections, I will propose and discuss two different levels (firm and region) of mediation factors that may facilitate or deter the link between technological diversification and firm performance (Sun, Hu, & Hillman, 2016).

This mediation model draws on the theoretical advances that distinguish between firms’ resources and dynamic capabilities (Eisenhardt & Martin, 2000). Previously, the dynamic capability view held that firms could continuously renew and reconfigure their resource base (Teece, 2007). In this regard, the dynamic can be understood as “change”, while the capability can be regarded as “process” (Ambrosini & Bowman, 2009; Helfat & Peteraf, 2009). Many scholars have theoretically positioned firms’ capability as routines embedded in their daily work and tasks (Arend & Bromiley, 2009; Zollo &

Winter, 2002). In this regard, dynamic capabilities are routines to learn new routines (Adler et al., 1999; Eisenhardt, Furr, & Bingham, 2010; Schilke, 2014). Scholars have identified several micro-foundations of dynamic capabilities, such as research and design (R&D) (Lane & Lubatkin, 1998), regional foreign direct investment (Ning, Wang, & Li, 2016), and institutional infrastructure (Gao et al., 2017).

Dynamic capability, in a nutshell, can sense, seize and reconfigure firms' capacities (Teece, 2007). Sensing indicates firms' capability to identify opportunities, seizing is the capability to utilise and invest in those opportunities, and reconfiguring is the capability to integrate firms' resources to implement those tasks.

While early literature documented that dynamic capability referred to a firm's resources and made no distinction between firms' resources and firms' dynamic capability, recent studies suggest that the RBV and the dynamic capability view should be understood as complementary concepts (Sirmon & Hitt, 2009). They are neither monolithic constructs nor two separate and orthogonal concepts. Instead, they are intertwined to influence firm performance (Helfat, 1997; Helfat & Peteraf, 2009). Helfat and Peteraf (2009) proposed a framework, which is illustrated in Figure 6-1, that best describes the rationale behind my following sections.

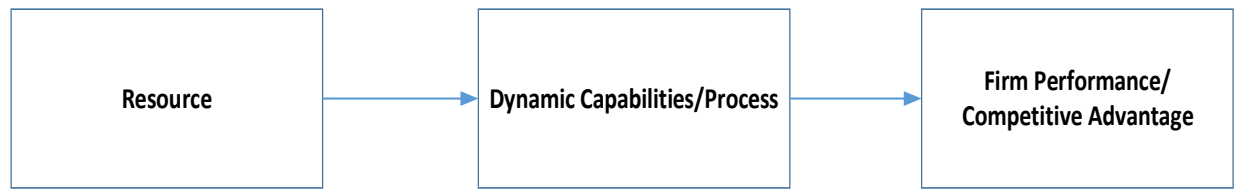


Figure 6- 1 Basic logic between resource and dynamic capability; Adapted from Helfat and Peteraf (2009) and Eisenhardt and Martin (2000)

Since legitimacy can also be understood as a resource that can be acquired and manipulated by organisations, the mechanical view and the institutional view can thus also be integrated into the consideration of firms' resources (Dacin et al., 2002; Kostova et al., 2008; Oliver, 1991, 1997). Thus, a missing link, following Figure 6-1, is the configuration of dynamic capabilities that connect the firms' resources to its performance. Firms' resources are expected to translate into a competitive advantage through dynamic capabilities, and dynamic capabilities rest on firms' processes, which can alter its current position to generate returns (Li-Ying et al., 2016).

Based on the resource-based view and dynamic capability view, I argue that firms' dynamic capabilities can mediate firms' resources such as technological diversification. Besides the moderating effect discussed earlier, I, therefore, propose a mediation model that may further encourage technological diversification in the future. I will explain some key concepts and the recent advances in mediation testing to further elaborate the mediation model. First, from the mechanical view, technological diversification is a

firm resource. Apart from understanding the RBV, technological diversification can also be regarded as a means to reduce environmental uncertainty (Pfeffer & Salancik, 1978; Xia et al., 2014) and to reduce the transaction costs from buying technologies from the market (Leten et al., 2007; Miller, 2006). Thus, technological diversification, from the mechanical view, can be taken as a firm resource that is used to build competitive advantage.

Apart from the mechanical view, technological diversification can be regarded as an incentive to acquire organisational legitimacy. In this view, legitimacy can also be understood as an asset to the firm and a resource that can be accessed. As illustrated earlier, the state, the media, public opinion and individuals can be sources of organisational legitimacy. Firms thus can leverage different strategies to affect these entities and get access to legitimacy (Oliver, 1997). For example, firms can gain legitimacy by lobbying government officials and thus influencing policy makings (Dacin et al., 2002; Stevens, Xie, & Peng, 2016). In this regard, from an institutional view, technological diversification can also be regarded as a firm resource that can be used to access legitimacy.

Firm-level mediation effect

Technological diversification is a firm choice whereby the firm exploratively and

exploitatively cultivates multiple technologies (Garcia-Vega, 2006; Suzuki & Kodama, 2004). In order to achieve economies of scope, firms should build internal competence (Laursen & Salter, 2006) such as in-house R&D to explore the benefits of technological diversification.

In-house R&D is a prerequisite for firms to build absorptive capability (Cohen & Levinthal, 1990). R&D also represents the typical type of dynamic capability, whereby firms recombine and reconfigure their resources to learn new routines (Lane & Lubatkin, 1998). In-house R&D can help firms to reduce their learning costs in terms of time and efficiency (Fleming, 2001). In-house R&D can also help enhance firms' internal to-do capabilities to capture the value of their existing resources (Chandrashekhar, 2006). This is especially important for deepening our understanding of multiple technologies, which is referred to as exploitative technological diversification. As I discussed in Chapter 2, exploitative technological diversification has often been neglected in the previous research. However, firms can also refine and deepen their knowledge of multiple technologies, thus meaning that technological diversification can be regarded as exploitation. This exploitation needs in-house R&D to build internal know-how to realise the potential (O'Reilly & Tushman, 2008).

Moreover, in-house R&D investment can improve a firm's ability to absorb, assimilate,

and extend its ability to search for external technologies (Leal-Rodríguez, Ariza-Montes, Roldán, & Leal-Millán, 2014). This is especially important for explorative technological diversification, which refers to expanding technologies beyond firms' current technological portfolios. When firms try to expand their technology portfolios, they must either purchase from the market or develop capabilities within the firm boundaries. As exploitative technological diversification is related to developing technological capability within firms, R&D can also help firms to acquire technologies from the market. First, R&D as an absorptive capability can help firms explore potential technologies at the market. Second, R&D can also help firms to assimilate those technologies bought from the market and build technological capabilities in the expanded fields. In sum, R&D can also help firms to undertake exploitative technological diversification.

Apart from those benefits, as a potential absorptive capability, R&D can also help firms to realise its performance benefits. As Zahra and George (2002) indicated, there are two types of absorptive capability, which are referred to as potential absorptive capability and realised absorptive capability. Their proposition can be found in Figure 6-2.

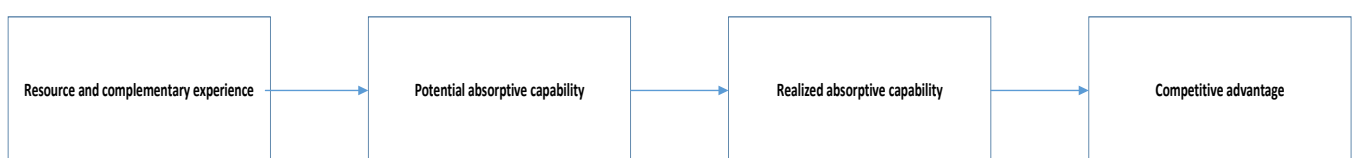


Figure 6- 2 Absorptive capability framework, adapted from Zahra and George (2002)

As depicted in Figure 6-2, the resources should link to competitive advantage via potential and realised absorptive capability. As R&D is a type of potential absorptive capability, it can help technological diversification link to competitive advantage. Thus:

Proposition 6-1: A firm's in-house R&D investment mediates the relationship between technological diversification and the firm's technological innovation performance.

Regional level mediation effect

Apart from the firm level mediator, I also argue that there are some regional level factors that can link technological diversification to firm performance. As Zahra and George (2002) indicate, the absorptive capability can be distinguished as potential and realised absorptive capability. As I regard in-house R&D as potential absorptive capability, I consider technology market turnover as the regional mediator that can possibly link technological diversification to firm performance. Technology market transaction turnover is a regional realised absorptive capability. Technology market transaction turnover refers to the total amount of sales in the technology market. This factor reflects the regional marketability, which can translate technologies into profits (Wang, Pan, Ning, Li, & Chen, 2015). As innovation can be referred to, on the one hand, as new ideas and production, and on the other hand, as the commercialisation of these ideas

and products (Chesbrough, 2003), the technology market transaction turnover can indicate the regional ability to translate innovative ideas into the markets.

In the context of technological diversification, whether or not technological diversification will profit relies heavily on its regional ability to translate the technologies into products. Zahra and George (2002) refer to realised absorptive capability as the efficiency factor and state that realised absorptive capability could approach the outputs of potential absorptive capability. In this sense, in-house R&D can help firms to become versatile in multiple technologies, both exploratively and exploitatively; the regional technology market transaction is the regional capability that realises the multiple capabilities within firms. In this sense, I argue that as a realised absorptive capability, technology market transaction turnover also can mediate the relationship between technological diversification and firm performance. Hence:

Proposition 6-2 Regional market transaction turnover mediates the relationship between technological diversification and the firm's technological innovation performance.

Besides regional realised absorptive capacity, there are also some factors that can be regarded as potential absorptive capability at the regional level. I argue that regional

FDI can be regarded as a potential absorptive capability. FDI has been recognised as a key external source of newly created and advanced knowledge, allowing international technology transfers to take place from developed countries to host regions. Many advanced technologies are transferred to under-developed regions. As a result, firms in these under-developed regions benefit from interacting with foreign firms and exchange information with these partners (Fu, 2008; Fu & Gong, 2011). Therefore, firms in emerging countries such as China are building their technology capabilities and catching up with their Western counterparts through learning from multi-national enterprises (MNEs) (Crespo & Fontoura, 2007; Ning, 2009; Ning et al., 2016). Regions in China are the main recipients of FDI activities, and thus they provide an ideal background for a local firm to absorb advanced technologies.

A typical effect of FDI is spillover. FDI spillover is geographically bounded when local firms co-locate and closely interact with MNEs within a specific region (Cheung & Lin, 2004; Wei & Liu, 2006). FDI spillover can contribute to local technology upgrading and enhance regional absorptive capability (Görg & Greenaway, 2004; Meyer, Estrin, Bhaumik, & Peng, 2009). In this sense, local firms will increase their know-how ability when they interact with MNEs. When foreign firms expand into regions, foreign investors often exploit and demonstrate their advanced technology in their subsidiaries. They do this for two main reasons. First, local governments may provide benefits and

policies if they can transfer their advanced technologies to their local subsidiaries. Second, in order to gain local legitimacy, they need to demonstrate their ability to benefit the local community with their superior technologies (Stevens & Newenham-Kahindi, 2017; Stevens et al., 2016).

In the context of technological diversification, I argue that regional FDI can serve as an important potential absorptive capability that helps firms to expand their technology portfolios. Regional FDI, on the one hand, can bring unfamiliar technologies to local firms to help them expand their technical fields, thus increasing the explorative technological diversification. On the other hand, local firms can deepen their understanding of multiple technologies while interacting with MNEs. They can get a better understanding of how to allocate human capital in technologies, and how to manage resources within and between firms when they are doing business with MNEs. Thus, regional FDI can serve as a potential absorptive capability to mediate the relationship between technological diversification and firm performance. Hence:

Proposition 6-3 Regional FDI mediates the relationship between technological diversification and a firm's technological innovation performance.

In summary, in Figure 6-3, I propose a technological diversification research model

based on the previous chapters and aforementioned discussions.

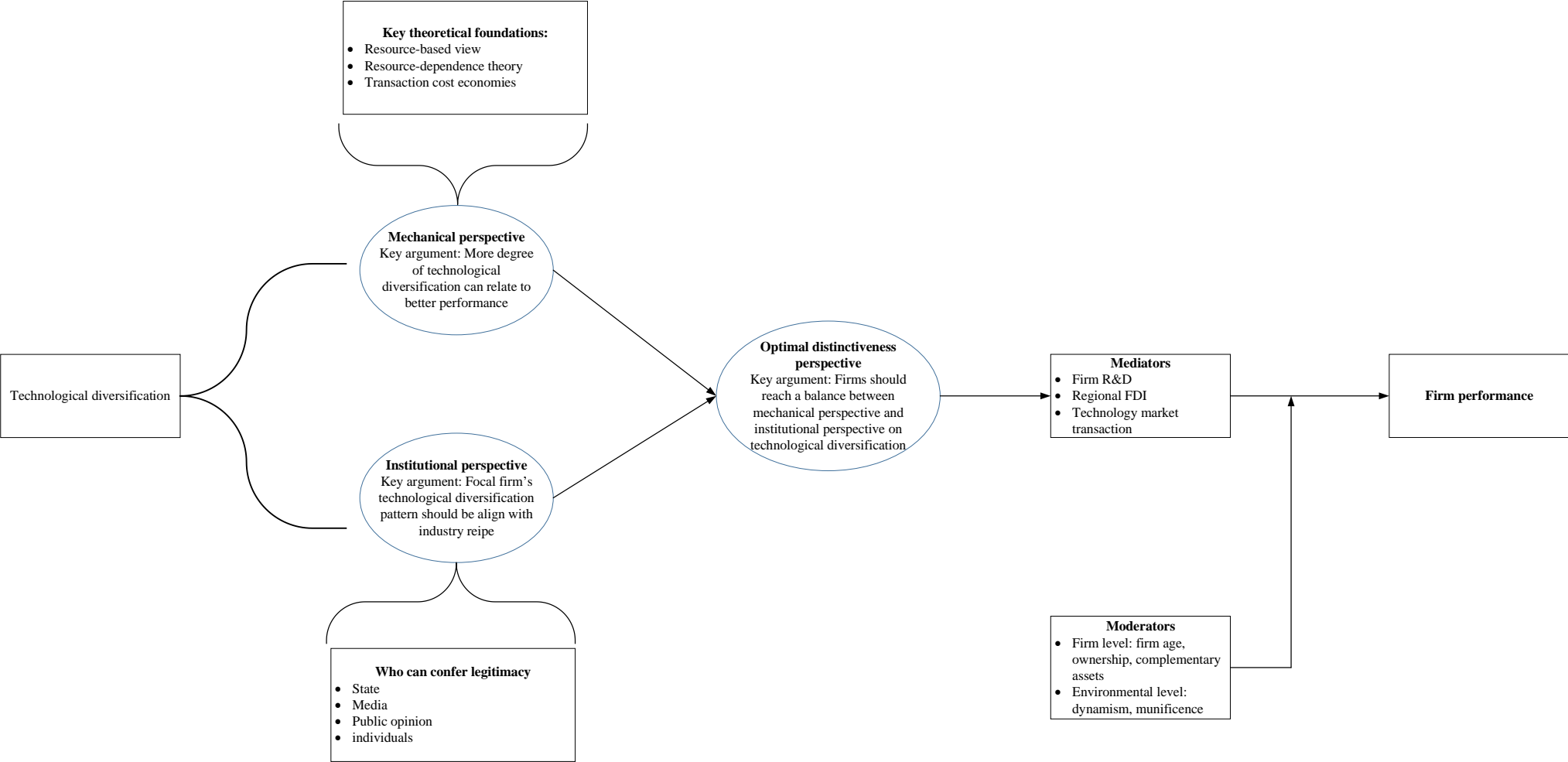


Figure 6- 3Technological diversification research framework

6.4 Methodologies of the mediation effect

The structural equation model (SEM) has been adopted widely and extensively to test the mediation effect in the psychology, marketing and communication literature, among others (Barrett, 2007; Byrne, 2001; Ko & Stewart, 2002; Schreiber, Nora, Stage, Barlow, & King, 2006). One explanation for this may be the nature of the data used in these streams of study. In marketing and psychological studies, questionnaire and survey data are often used to test the hypotheses. These data, in nature, are cross-sectional and can hardly be expanded to panel data models. Thus, scholars resort to the model proposed by Baron and Kenny (1986) when studying panel data mediation effects (e.g. Gielnik, Spitzmuller, Schmitt, Klemann, and Frese (2015); Li-Ying et al. (2016); Rodríguez and Nieto (2016). However, recent methodological advances have demonstrated that the model is redundant and may fail to support what it claims (Zhao, Lynch, & Chen, 2010).

A typical Baron and Kenny model of mediation effects is illustrated in Figure 6-4.

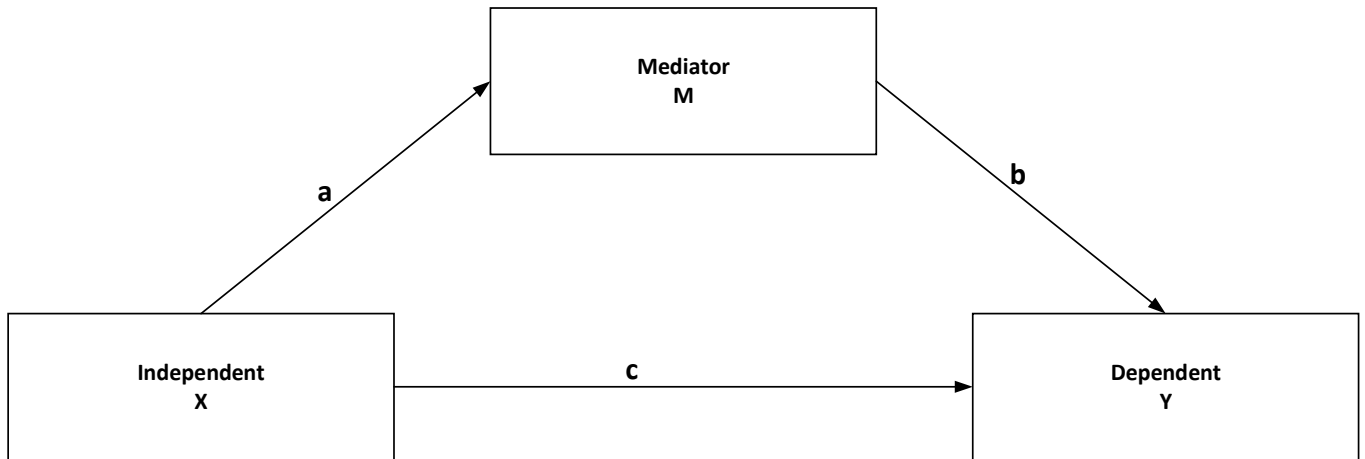


Figure 6- 4Mediation effect model

As suggested by Baron and Kenny (1986, 1176), three tests should be made to verify the hypothesised mediation effect:

A variable functions as a mediator when it meets the following conditions: (a) variations in levels of the independent variable significantly account for variations in the presumed mediator (i.e., Path a), (b) variations in the mediator significantly account for variations in the dependent variable (i.e., Path b), and (c) when Paths a and b are controlled, a previously significant relationship between the independent and dependent variables is no longer significant, with the strongest demonstration of mediation occurring when Path c is zero.

In other words, their independent regressions should be tested:

$$M = i_1 + aX + e_1 \quad (\text{equation 6-1})$$

$$Y = i_2 + c'X + e_2 \quad (\text{equation 6-2})$$

$$Y = i_3 + cX + bM + e_3 \quad (\text{equation 6-3})$$

Then these authors argue that to test mediation, one should estimate the three following regression equations: first, regressing the mediator on the independent variable; second, regressing the dependent variable on the independent variable; and third, regressing the dependent variable on both the independent variable and the mediator. *To establish mediation, the following conditions must hold: First, the independent variable must affect the mediator in the first equation; second, the independent variable must be shown to affect the dependent variable in the second equation; and third, the mediator must affect the dependent variable in the third equation (1986,1177).*

Furthermore, Baron and Kenny also suggest a Sobel test that can investigate the significance of the indirect path $a \times b$

$$z = \frac{a \times b}{\sqrt{b^2 s_a^2 + a^2 s_b^2}} \quad (\text{equation 6-4})$$

Where a and b are the coefficients of paths a and b respectively, and s_a and s_b are the standard errors of a and b from equations 1 and 3 respectively.

However, the Sobel test is ineffective and may too constrain to indicate a mediation effect (Preacher & Hayes, 2008). Zhao et al. (2010) proposed that the only criterion that establishes a mediation effect is that $a \times b$ should be significant. The Sobel test is low in power compared with the bootstrapped resampling method proposed by Preacher and Hayes (2004). In conclusion, the regression of equation 6-2 is redundant, and the Sobel test should be implemented through high power bootstrapped sampling.

Preacher and Hayes (2004) proposed a SAS program and SPSS macro to implement the bootstrapped Sobel test. Their implementation is cross-sectional in nature; however, it can be easily expanded into panel data models. I strongly suggest that future research should adopt this procedure to do the mediation test.

Appendix

Table A. IPC classification used in this thesis

Classification	Name
A	Human necessities
B	Performing operations; Transporting
C	Chemistry; Metallurgy
D	Textiles; Paper
E	Fixed constructions
F	Mechanical Engineering; Lighting; Heating; Weapons; Blasting
G	Physics
H	Electricity

Table B. Variable definition in chapter 3

Variables	Equation	Definition
		MV= (Total shares -B Share) ×Closing price of A share + B Share × Closing price ×Exchange Rate.
Tobin's Q	$Tobin's Q = \frac{MV}{TA}$	TA is the total assets disclosed in the balance sheet
Technological diversification	Explorative technological diversification ×Exploitative technological diversification	$Explorative TD = \sum_{j=0}^n P_j \ln 1 / P_j$ $Exploitative TD = \sum_{j=0} \frac{X_{ij}}{\sum_j X_{ij}}$
High or low-tech firms		Firms operate in raw chemical materials and chemical products (C43); chemical fibres (C47); electronics (C5); instruments, meters, cultural, and clerical machinery (C78); pharmaceuticals (C8); and information technology (G) will be regarded as high-tech firms
Intangible complement	$Complementary assets = \frac{Intangible assets}{Total assets}$	Intangible assets include patent, non-patent technology, trademark, copyright, VAD ratio

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ary assets	land use right, etc VAD ratio is calculated by dividing the value added by the sales of the firm. Where the value added is calculated as the sum of the profit, wage expenses, depreciation, welfare expenses, interest and taxation.
Independent director	the fraction of the overall number of directors
Board size	number of board members to measure this variable
Firm age	deducting the current observation year from the year in which the firm was first listed on the stock market
Firm size	natural log of the total assets
Leverage	total debt divided by the total assets
EM	Firm profit, regression slope (β), divide by mean (\bar{Y})
ED	Firm profit, standard error (S_b), divide by mean (\bar{Y})

Table C. Variable definition in chapter 4

Variables	Equation	Definition
		MV= (Total shares -B Share) ×Closing price of A share + B Share × Closing price ×Exchange Rate.
Tobin's Q	$Tobin's\ Q = \frac{MV}{TA}$	TA is the total assets disclosed in the balance sheet
Technological diversification	$P_{mi} = \frac{F_i F'_m}{((F_i F'_i)(F_m F'_m))^{1/2}}$	The technological diversification conformity
Conformity	Where $F_i = (N_{i1}, \dots, N_{i2}, \dots, N_{ij})$	between the m_{th} industry average and the

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	technological space of the i_{th} firm, and N_{ij} is the number of patents that the i_{th} firm holds in the technological category j ($j = (1, 2, \dots, 8)$).	i_{th} firm in the m_{th} industry
Independent director		the fraction of the overall number of directors
Board size		number of board members to measure this variable
Firm age		deducting the current observation year from the year in which the firm was first listed on the stock market
Firm size		natural log of the total assets
Leverage		total debt divided by the total assets
EM		Firm profit, regression slope (β), divide by mean (\bar{Y})
ED		Firm profit, standard error (S_b), divide by mean (\bar{Y})

Table D. Variable definition in chapter 5

Variables	Equation	Definition
		MV= (Total shares -B Share) ×Closing price of A share + B Share × Closing price ×Exchange Rate.
Tobin's Q	$Tobin's Q = \frac{MV}{TA}$	TA is the total assets disclosed in the balance sheet
Technological diversification Conformity	$P_{mi} = \frac{F_i F_m'}{((F_i F_i')(F_m F_m'))^{1/2}}$	The technological diversification conformity between the m_{th}

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	<p>Where $F_i = (N_{i1}, \dots, N_{i2}, \dots, N_{ij})$ is the industry average and the i_{th} firm in the m_{th} technological space of the i_{th} firm, and N_{ij} is the industry number of patents that the i_{th} firm holds in the technological category j ($j = (1, 2, \dots, 8)$).</p>	
Independent director		the fraction of the overall number of directors
Board size		number of board members to measure this variable
Firm age		deducting the current observation year from the year in which the firm was first listed on the stock market
Firm size		natural log of the total assets
Leverage		total debt divided by the total assets
State ownership		1 if the firms controlled by the state and related agencies, 0 otherwise
EM		Firm profit, regression slope (β), divide by mean (\bar{Y})
ED		Firm profit, standard error (S_b), divide by mean (\bar{Y})

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